IMPACT OF THE SUPERVISED CREDIT SYSTEM ON THE USE OF MODERN AGRICULTURAL PRACTICES: THE CASE OF CORN IN GUATEMALA

BY

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Chairman: W. W. McPherson
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Major Department: Food and Resource Economics

In 1970 the government of Guatemala embarked upon a new development plan, an important element of which was the modernization of small-farm agriculture. One important instrument used to promote this modernization was supervised credit which was provided primarily in an attempt to raise the yields of traditional food crops, such as corn, through the adoption of modern inputs and modern agricultural practices. The agents of the newly created Agricultural Development Bank (BANDESA) were to manage and provide the credit funds, whereas the agricultural promoters of the General Directorate for Agricultural Services (DIGESA) were charged with providing technical assistance and the technical monitoring of the use made of these funds.

The evidence available from previous studies of the impact of the Supervised Credit System of Guatemala (SCSG) indicates that, despite its intended objectives, farmers who received BANDESA credit did not have the yield advantage over non-BANDESA farmers which had been hoped for. On the basis of the evidence available in the Small Farmer BANDESA Credit Survey which was derived from a cross section of farmers, and

with a focus on the production of non-interplanted corn, the objectives of the present study are to determine the extent to which BANDESA's credit and DIGESA's technical assistance were effective in (a) inducing farmers to use modern inputs (specifically: improved seeds, fertilizers, insecticides and machinery) and (b) assisting farmers in making effective use of the chosen technology.

The study develops a theoretical framework which guides subsequent statistical analysis. A multivariate logit model is used to evaluate the effect of various factors which could potentially determine the probability of modern input use. Also, several production response surfaces within technologies are estimated to help understand the productivity effect of the various aspects of the SCSG.

On balance, participation in the SCSG was found to be associated with increased use of the four modern inputs considered. Nevertheless, the evidence suggests that the SCSG did not promote the use of every one of these inputs. Instead, various aspects of the assistance provided by the SCSG appear to have had a differentiated or selective effect in terms of inducing the use of the individual inputs considered.

The evidence also indicates that some of the corn technologies which used modern inputs were productive. Furthermore, technical assistance on corn also helped improve farmer productivity. Nevertheless, it appears that BANDESA farmers were significantly less productive in corn production than their non-BANDESA counterparts. The evidence examined suggests, as one explanation of this perplexing result, that there was an inefficient use of resources on the part of BANDESA farmers as a consequence of the subsidized terms on which the credit funds were loaned.

The study concludes with a set of recommendations for the design and evaluation of future programs which include the following: (a) programs should focus on final objectives (such as improving private, economic and social profitability), rather than intermediate objectives (such as raising yields); (b) programs should be justified on a more solid technical basis than the SCSG appears to have been (specific necessary conditions for the success of supervised credit programs are discussed in the text); (c) credit should not be provided on a subsidized basis; (d) not all employment creation should be deemed beneficial; (e) strategies for improving the incomes of Guatemala's small farmers should include the promotion of modern but profitable practices and should take cognizance of significant regional differences in agronomic, economic and social conditions; and (f) future research efforts should focus on assessing direct objectives, giving explicit consideration to factors affecting risk and include post-implementation evaluations of programs.

CHAPTER I
INTRODUCTION

Performance of the Guatemalan Economy 1960-1976[1]

Between 1960 and 1976 Guatemala experienced a rate of growth of about 5.6 percent in its gross domestic product, a rate which was about equal to the growth rate experienced by Latin America as a whole. Much of the growth experienced, particularly during the 1960's, was stimulated by trade within the Central American Common Market. Such trade also helped keep the country's balance of payments in current account deficit to a minimum and allowed Guatemala to diversify its exports. By 1976 the value of coffee as an export crop dropped to about 30.5 percent of the value of total exports, a decrease from 64.4 percent in 1960. Over the same period the value of exports of manufactured goods as a proportion of total exports increased from 7.9 percent to 33.4 percent (Table 1).

The reduction in Guatemala's external sectors' vulnerability to the fluctuations in world coffee prices did not come about as the result of weaknesses within the agricultural sector. Overall demand for Guatemala's traditional agricultural exports--namely, coffee, bananas and cotton--remained strong during this period. Industry took on an added importance and the economy experienced a period of balanced growth.

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[1]This section is based on World Bank [1978].

Table 1. Exports by product, Guatemala, 1960-1976[a]

Product	1960	1965	1969	1970	1971	1972	1973	1974	1975	1976
Agricultural products--value	105.0	142.4	150.3	163.5	154.5	190.2	241.6	309.7	294.7	389.2
Coffee										
Value	74.6	91.7	81.4	100.6	96.3	105.3	145.6	172.9	164.2	242.5
Quantity	79.9	95.3	99.6	95.1	100.0	113.7	114.8	121.1	133.8	117.8
Price	93.0	96.0	81.7	105.7	96.2	92.6	126.8	142.8	122.7	205.8
Cotton										
Value	5.8	34.4	40.3	27.2	26.0	40.9	47.9	71.0	74.0	83.7
Quantity	12.1	70.6	84.1	57.7	55.6	85.1	98.2	126.2	96.4	93.1
Price	48.0	49.0	48.0	47.1	46.8	48.1	48.7	56.3	76.7	89.9
Bananas										
Value	17.3	4.9	11.8	13.6	14.5	25.6	24.7	31.5	34.5	41.3
Quantity	189.0	34.1	114.6	200.4	235.8	270.8	263.2	298.9	263.8	265.9
Price	9.0	13.0	8.1	6.8	6.1	9.5	9.4	10.5	14.6	15.5
Other agricultural products--value	7.3	11.4	16.8	22.1	17.7	18.4	23.4	34.3	22.0	21.7
Mineral products--value	1.5	0.4	4.4	4.4	3.4	3.8	6.6	8.4	8.2	8.2
Industrial goods--value	9.4	49.3	107.8	129.2	129.0	141.8	193.4	264.1	338.0	396.9

Table 1. Continued.

Product	1960	1965	1969	1970	1971	1972	1973	1974	1975	1976
Processed agricultural products--value	0.3	8.8	18.7	21.9	27.3	34.1	47.0	71.1	132.5	131.8
Sugar										
Value	0.1	4.2	6.7	9.2	9.9	16.1	21.9	49.6	115.6	111.0
Quantity	0.7	31.6	46.0	57.3	66.7	91.2	126.2	134.2	200.7	302.7
Price	10.0	13.0	14.5	16.0	14.8	17.4	17.4	36.9	57.6	36.7
Beef										
Value	0.2	4.6	12.0	12.7	17.4	18.0	25.1	21.5	16.9	20.8
Quantity	0.5	5.8	12.3	12.1	16.2	15.4	17.3	13.7	12.2	14.5
Price	38.0	79.0	97.7	104.9	107.0	117.5	145.6	157.1	138.5	143.4
Manufactured goods[b]--value	9.1	40.5	89.1	107.3	101.7	107.7	146.4	193.0	205.5	265.1
TOTAL VALUE	115.9	192.1	262.5	297.1	286.9	335.8	441.6	582.2	640.9	794.3

[a]Value in million dollars, quantity in thousand metric tons, price in cents per kilogram.

[b]Includes miscellaneous processed agricultural products.

SOURCE: World Bank [1978, Statistical Annex, Table 3.2(1)].

The relative contributions of primary, secondary and tertiary activities to gross domestic product showed relatively minor changes from 30.5, 15.6 and 53.9 percent, respectively, in 1960, to 27.4, 20.2 and 52.4 percent in 1976 (Table 2).

The liberal trade policies together with almost balanced public expenditure budgets kept the rate of inflation at less than 0.5 percent per year during the 1960's. Subsequently, the economy showed a remarkable buoyancy in dealing with three major crises: (a) the breakdown of the Central American Common Market following the El Salvador-Honduras was of 1969; (b) the steep increases in oil prices in 1973; and (c) the 1976 earthquake. Prices rose sharply as a consequence of these events. Between 1972 and 1976 consumer prices in Guatemala City rose at a rate of 10 to 15 percent per year. But, the basic health of Guatemala's growth and balance of payments position was not undermined.

Income Distribution

Despite the satisfactory performance of macroeconomic indicators, the benefits of Guatemala's income growth have not been evenly distributed among its 6.3 million inhabitants.[2] The 25 percent of the population with the highest incomes in 1970 had a per capita income 10 times as high as that received by the lower income quartile (Table 3). Furthermore, a comparison with the data available for 1947-78 suggests that the degree of inequality in income distribution may have increased over time.

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[2]Mid-1976 population.

Table 2. Gross domestic product, Guatemala, 1967-1976 (millions of 1975 Quetzales)

Sector	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Primary production	627.6	698.1	719.2	757.2	810.2	894.3	940.5	991.3	1026.1	1076.2
Agriculture	624.8	695.9	717.0	754.6	807.6	891.9	938.1	988.2	1022.8	1072.1
Mining	2.8	2.2	2.2	2.6	2.6	2.3	2.5	3.1	3.3	4.2
Secondary production	420.3	462.8	498.6	513.0	545.8	589.3	643.1	660.2	671.2	792.5
Manufacturing	349.8	392.1	423.3	436.1	466.9	496.3	536.0	555.1	552.3	609.5
Construction	44.9	42.5	44.1	43.8	43.9	53.1	63.2	58.5	68.0	128.1
Public utilities	25.6	28.2	31.1	33.1	35.0	39.9	43.9	46.7	50.8	54.8
Services	1231.2	1331.1	1409.1	1492.5	1559.1	1669.5	1778.9	1891.0	1949.4	2053.0
Transport and storage	119.6	131.3	142.5	151.3	162.5	183.6	202.3	226.4	233.7	258.2
Commerce	639.3	710.2	744.4	798.2	834.8	884.0	944.1	1006.2	1005.5	1090.7
Banking, insurance and finance	53.6	55.7	59.2	65.2	67.1	72.5	82.6	88.6	95.0	101.5
Housing	175.9	182.1	188.7	192.3	196.2	201.6	205.2	206.9	215.0	173.6
Public administration and defense	110.5	112.8	127.9	133.9	135.7	151.3	154.7	163.5	183.2	195.9
Personal services	132,3	139.0	146.4	151.5	162.8	176.5	190.0	199.4	217.0	233.1
Gross domestic product	2279.0	2491.9	2626.9	2762.7	2915.1	3153.0	3362.6	3542.5	3646.7	3921.8

SOURCE: World Bank [1978, Table 2.1].

Table 3. Personal income distribution, Guatemala, 1947-48 and 1970

Quartile	1947-78	1970			
	Percent of total income	Percent of total income	Average per family income	Per capita annual income	Inequality coefficient
			---------- Quetzales ----------		
I	7.0	6.7	438	81	1.0
II	15.5	10.7	700	130	1.6
III	17.0	16.1	1055	195	2.4
IV	60.5	66.5	4346	804	9.9
I - IV	100.0	100.0	1635	302	3.7

SOURCES: World Bank [1978, Table 2.1] and Daines et al. [1976, Vol. I, p. 25].

This skewness in income distribution is closely related to the low level of modernization of Guatemala's productive structure and the degree of inequality in resource ownership. Agricultural employment amounted to about 57 percent of the economically active population in 1973 (Table 4) but, as a result of low productivity, it accounted for only 28 percent of the gross domestic product.

Dualism in Guatemalan Agriculture

Commercial agriculture was the dominant force behind the healthy performance of the agricultural sector and it provided much of the strength exhibited by the general economy between 1960 and 1976. This subsector provided a substantial proportion of the savings reinvested in the economy and the raw materials for the country's industrial development and export diversification.

Over the 1967-76 period the values of export crops, livestock and industrial raw materials increased by 65.1, 92.3 and 197.9 percent, respectively. In contrast, the value of locally consumed crops and of the four major basic grains taken together--corn, beans, wheat and rice--increased over the same period by only 30.9 and 19.3 percent, respectively (Table 5).

This dual structure of Guatemalan agriculture constitutes one of its most distinctive features.[3] A modern, dynamic and capital intensive system employs modern practices in the cultivation of the better endowed lands, where the infrastructure is more highly developed in the

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[3]This is a fairly useful distinction frequently employed in analyzing problems in Guatemala. For a similar, more complete treatment, see Fletcher et al. [1970].

Table 4. Economically active population by sector, Guatemala, 1950, 1964 and 1973

Sector	1950	1964	1973	Average annual rate of growth	
				1950-64	1964-73
	------- Thousand --------			----- Percent -----	
Agriculture	578	785	798	2.2	0.2
Mines and quarries	1	2	2	2.4	1.7
Manufacturing	109	141	205	1.9	4.3
Construction	26	36	61	2.3	6.2
Electricity	1	2	4	1.9	10.6
Commerce	51	82	111	3.4	3.4
Transport	15	29	38	4.9	3.0
Services	93	151	186	3.5	3.3
TOTAL	874	1226	1405	2.4	1.5
	-- Percentage distribution --				
Agriculture	66.1	63.9	56.7		
Mines and quaries	0.2	0.2	0.2		
Manufacturing	12.4	11.5	14.6		
Construction	2.9	2.9	4.3		
Electricity	0.1	0.1	0.3		
Commerce	5.9	6.7	7.9		
Transport	1.7	2.4	2.7		
Services	10.7	12.3	13.3		
TOTAL	100.0	100.0	100.0		

NOTE: Population 15 years and over; excludes unidentified occupations.

SOURCE: World Bank [1978, Table 1.2].

Table 5. Value of agricultural production, Guatemala, 1967-1976 (millions of 1958 Quetzales)

Item	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Crops	287.3	305.9	310.5	320.3	333.5	380.2	407.1	445.3	452.8	473.7
Export crops	142.1	158.8	160.0	162.9	168.5	199.5	216.8	247.9	233.5	234.6
Coffee	87.8	96.4	98.4	108.5	110.1	122.3	127.3	139.4	140.8	134.1
Cotton fiber	36.9	41.4	37.1	29.6	33.6	45.0	52.9	63.5	54.5	56.9
Bananas	8.3	12.9	16.2	16.8	17.8	23.4	25.2	32.0	27.0	29.2
Cotton seed	4.0	4.6	4.2	3.3	3.7	4.9	5.9	6.8	5.2	6.3
Cardamon	1.8	2.1	2.0	3.3	2.4	2.2	4.0	5.0	5.3	6.7
Other	3.4	1.4	2.2	1.4	0.9	1.7	1.5	1.0	0.7	1.4
Crops for local cons.	112.3	114.3	116.9	121.2	122.7	128.2	133.5	138.1	149.3	147.0
Basic	60.0	59.9	61.0	63.6	63.1	65.1	68.1	69.0	78.3	73.5
Corn	32.8	32.4	33.1	36.3	35.5	35.5	38.2	37.5	43.8	39.4
Beans	25.7	26.3	26.6	25.8	26.0	27.5	27.6	27.8	29.1	28.3
Potatoes	1.4	1.2	1.3	1.5	1.6	2.0	2.3	3.7	5.4	5.8
Other	52.4	54.5	55.9	57.6	59.6	63.2	65.4	69.1	70.9	73.5
Fruits	19.5	20.1	20.8	21.4	22.1	22.8	23.5	24.2	24.9	25.7
Vegetables	18.0	18.5	19.1	19.7	20.3	20.9	21.6	22.2	22.9	23.7
Lima beans	1.1	1.1	1.1	1.2	1.2	1.2	1.3	1.3	1.4	1.4
Peanuts	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Lentils	--	--	--	--	--	--	--	--	--	--
Other	13.7	14.6	14.8	15.3	15.9	18.1	19.0	21.2	21.6	22.6
Industrial raw materials	32.9	32.8	33.5	36.1	42.4	52.4	56.8	59.3	70.1	92.1
Sugarcane (natural)	--	11.1	12.4	13.2	13.9	18.2	21.8	24.1	28.6	41.9
Sugarcane (pure syrup)	20.7	2.4	2.6	2.8	3.0	3.9	4.7	5.2	6.2	9.0

Table 5. Continued.

Item	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Sugarcane (brown sugar)	--	5.5	6.2	6.6	6.9	9.1	10.9	12.0	14.3	20.9
Wheat (unmilled)	3.1	4.5	3.1	4.1	4.6	5.9	5.0	5.3	6.7	6.2
Rice	2.5	2.7	2.9	2.5	6.4	6.6	4.8	2.3	5.0	2.6
Tobacco	2.0	1.8	1.9	2.1	2.4	2.8	3.5	4.0	4.1	4.0
Rubber	1.9	2.1	2.3	2.3	2.4	2.4	2.5	2.4	2.5	3.7
Té de limón	0.7	0.6	0.6	0.9	0.7	0.7	0.6	0.7	0.3	0.2
Kenaf fiber	0.8	0.9	0.7	0.8	0.6	0.6	0.7	0.9	0.8	0.9
Citronella	0.4	0.2	0.2	0.1	0.1	0.3	0.3	0.3	0.2	0.2
Sesame seed	0.6	0.8	0.4	0.4	1.0	1.6	1.9	1.5	0.5	2.1
Cocoa	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.5	0.9	0.4
Barley	--	--	--	--	--	--	--	--	--	--
Livestock sector	119.0	126.5	155.0	172.6	196.4	203.3	207.3	209.5	210.4	228.8
Non-meat products	--	66.4	81.4	92.9	101.1	109.8	114.2	111.2	111.8	125.9
Meat products	--	43.7	53.6	62.4	74.5	72.9	72.0	71.8	69.7	73.2
Beef	--	18.1	22.1	30.7	38.8	40.1	38.7	38.4	36.5	41.9
Pork	--	24.9	30.6	31.0	34.9	32.1	32.5	32.6	32.3	30.5
Sheep	--	0.6	0.7	0.6	0.6	0.6	0.6	0.7	0.8	0.7
Goats	--	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Fowl	--	16.4	20.1	17.3	20.8	20.7	21.1	26.6	29.0	29.7
Forestry	38.2	38.0	39.5	41.1	42.1	44.1	46.4	48.3	48.3	53.5
Hunting and Fishing	5.1	4.5	4.8	5.4	5.4	5.3	5.6	5.8	6.0	6.2
Inputs to agri. sector	41.4	43.7	46.9	49.6	53.1	58.2	61.3	65.2	66.0	70.1
Value added by sector	408.2	431.2	462.9	489.7	524.3	574.7	605.1	643.8	651.5	692.1
Gross value of production	449.5	474.9	509.8	539.3	377.4	632.9	666.4	709.0	717.6	762.2

SOURCE: World Bank [1978, Table 8.1].

production of domestically consumed commercial crops, such as sugar, vegetables, fruit, meat, wood and corn, and export crops, such as coffee, cotton and bananas. Alongside this modern system, a traditional low productivity agriculture is practiced on small farms which produce basic grains, mainly corn, wheat and beans, primarily for home consumption.

The two subsectors are, of course, not isolated from each other. In effect, many Indians who practice traditional agriculture in the Highlands seasonally migrate every year to work in the cotton and sugar harvests of large farms along the Pacific coast. Similarly, the production of basic grains is a very widespread activity (Table 6). According to the 1964 Agricultural Census, for instance, corn was grown on 93 percent of all Guatemalan farms, including many farms which can clearly be characterized as commercial.

The two subsectors differ in cultural heritage, agronomic practices, marketing problems faced, spatial location, ownership of land and capital resources. These differences jointly explain differences in recent economic performance and the prevalent patterns of income distribution. Most important, they provide a background against which the policies of the Government of Guatemala, in terms of the role assigned to agricultural transformation, may be understood.

Differences in the distribution of land in Guatemala underly much of the inequality in its income distribution. It is estimated that 83.3 percent of all farm families in 1970 were either landless or had land holdings of less than 4 hectares. Of the Central American countries, only El Salvador, with a population density three times higher, had a farming population with a slightly larger proportion of such small land holdings. At the other end of the scale, Guatemalan farms with 35

Table 6. Use of agricultural lands, Guatemala

Crops	Area	
	1,000 Hectares	Percent
Corn	660.0	51.2
Beans	177.2	13.7
Rice	19.9	1.5
Wheat	36.6	2.9
Sorghum	50.2	3.9
Coffee	207.0	16.6
Cotton	89.9	6.9
Sugarcane	43.2	3.4
Banana	5.0	

SOURCE: BID-IBRD-AID [1977, Annex 7, Table 1].

hectares and over were held by only 2.6 percent of the farm families and occupied 66.3 percent of the farm area [World Bank, 1978, pp. 72-73].

The differences in the distribution of land holdings have a spatial distribution which is closely related to the dual character of the agricultural sector. Population pressure and the use of traditional agricultural practices have led to a concentration of small farms in the Highlands both in the western part of the country and in the central region where Guatemala City is located. The concentration of 44.3 percent of Guatemala's farms in the Western Highlands, farming an area equal to about 26 percent of the country's farm land, contrasts sharply with the figures for the south coast and the rest of the country (Table 7).

The differences in income distribution by region, associated with the spatial distribution of farms by sizes, are further accentuated by the spatial distribution of the most rugged terrains. Except for the Petén, the coastal plains of the Pacific coast and a few isolated flood plains, the amount of land suitable for intensive agricultural use is very limited. Of a total area of 108,889 square kilometers, it is estimated that only 15 percent is suitable for intensive use and 27 percent for extensive agricultural use. The most infertile soils are found in the Western and Central Highlands (excluding Guatemala City) where the incidence of small farms is highest.

The population of Mayan heritage, comprising over 50 percent of the Guatemalan population, has historically occupied the Highlands, whereas the "ladinos" of Spanish descent colonized the more fertile lowlands of the Pacific coast. The 12 languages and numerous dialects identifiable in the Highlands have not facilitated cultural and commercial interchange.

Table 7. Regional distribution of population, output, farms, land and income, Guatemala

Region	Population (1975)		Gross domestic product (1972)	Rural families with incomes less than Q400	Average income in rural areas
	Total	Rural			
	----------------- Percent -----------------				--- Q ---
Central	27.6	10.2	53.0	12.1	444
South Coast	24.4	29.5	15.2	18.9	556
Western Highlands	24.8	31.0	17.9	40.3	346
Southeast	6.2	7.9	3.2	8.9	436
Northeast	6.5	9.8	5.6	7.1	645
Verapaces	7.8	10.8	0.4	12.0	399
Petén	0.6	0.7	0.5	0.7	481
TOTAL	100.0	100.0	100.0	100.0	442

Table 7. Extended.

Region	Farms (1964)	Farm area (1964)	Area		
			Land suitable for intensive use	Other land	Total
	-------	-------	Percent	-------	-------
Central	12.8	10.1	1	7	6
South Coast	14.8	29.2	44	5	11
Western Highlands	44.3	26.1	10	24	22
Southeast	8.3	8.2	2	5	5
Northeast	7.6	10.1	12	12	12
Verapaces	12.2	16.5	3	12	11
Petén	--[a]	--[a]	27	25	33
TOTAL	100.0	100.0	100	100	100

[a]Not considered in the calculation.

SOURCE: Daines et al. [1976, Vol. I, Chapter 2].

Guatemala's illiteracy rate, estimated at about 60 percent in the 1960's, stands out as one of the highest in Latin America. The rugged terrain of most of Guatemala has further hindered internal communication and the development of the country's infrastructure.

The spatial distribution of production reinforces the exhibited regional income disparities. On the Pacific coast, agricultural production is centered on high income export crops, such as coffee, sugar cane, bovine livestock, cotton, tea and rubber. Domestically consumed low income and low risk crops, such as corn and rice, are of secondary importance.

In the Western Highlands, where the family farm is the basic enterprise unit, the predominant crops are corn, wheat, beans and potatoes. Vegetables and fruits, which make intensive use of land and labor resources and are highly perishable, are only important in certain isolated zones of the Highlands, particularly in the vicinity of urban areas, in small patches of fertile soils or where irrigation is available. Ovine livestock, traditional in the area, is on the decline. Deciduous fruit, on the other hand, with some potential for expansion, has developed very slowly. It is primarily in the Highlands that a substantial proportion of the production of farms, mostly corn, is used in home consumption; i.e., where "subsistence" agriculture is most widely practiced.

In the Central, Southeast and Northeast regions, the production of basic grains is also the predominant activity. Milk production has some significance in the Southeast. Vegetables and fruits are of some importance in the Northeast.

In the Verapaces the predominant activities are the production of grains, vegetables and coffee. In the Peten, grains, livestock and forestry dominate.

Figure 1 shows the regional distribution by principal crops found to have been cultivated among farms sampled by the Small Farmer BANDESA Credit Survey (SFBCS).[4]

Given the observed dualism in Guatemala's agriculture and the spatial distribution of these two systems of farming in terms of differences in resource endowment, culture, population pressure and production activities, the regional differences in income distribution indicated in Table 7 are hardly surprising. While the regions with the lowest average income and the highest incidence of rural poor are the Highlands, the Verapaces and the Central, the wealthest regions are clearly the South Coast and the Northeast.

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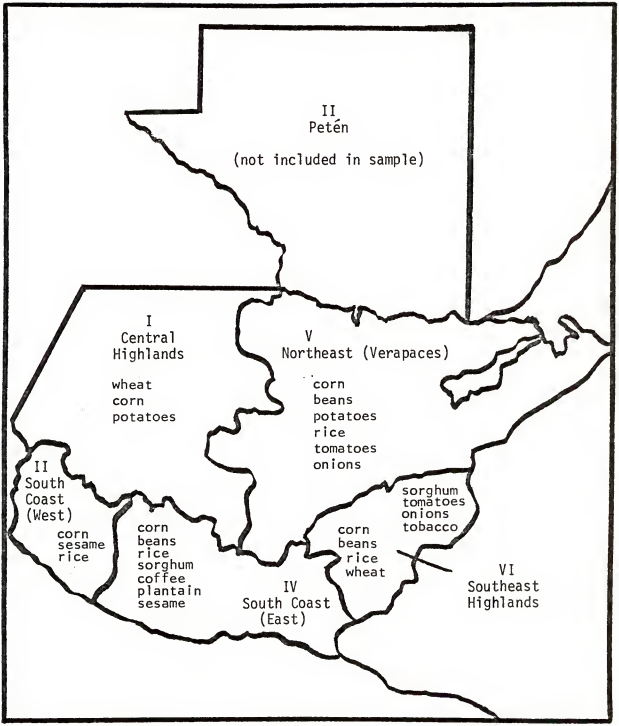
[4]The regional boundaries depicted in Figure 1 are those which were set by the Agricultural Development Plan and used in the design of the sample of the SFBCS. These boundaries loosely correspond to those used in previous discussions and shown in Table 7. Three differences may be noted. First, the Central and Western Highlands regions have been regrouped into a Central Highland region in Figure 1. Secondly, the Verapaces and Northeast regions have also been combined to form a Northeast region. Finally, a distinction is made in Figure 1 between the East and West parts of the South Coast. In the empirical analysis of the SFBCS presented in Chapters III, IV, and V of this study, the regional scheme depicted in Figure 1 is employed. The Roman numerals appearing on top of each regional name in Figure 1 are also used interchangeably to identify each of these regions throughout the remainder of the present study.



Important crops by region, Guatemala

SOURCE: Daines [1975a, p. 14].

The Supervised Credit System of Guatemala (SCSG)[5]

Genesis: The National Development Plan 1971-1975

Historically, public expenditures for agriculture in Guatemala have been low. Furthermore, a significant proportion of these expenditures has been aimed at developing the commercial sector, highways and other basic infrastructure, and at promoting colonization of the South Coast. Early in 1970, a new Government of Guatemala adopted the National Development Plan 1971-75. The plan recognized the importance of the agricultural sector in creating employment, generating income and foreign exchange and assigned the highest priority to its development. Perhaps most important, the plan had two major features of significance for the transformation of the traditional sub-sector within agriculture. First, the plan embarked upon an integrated effort of rural development aimed at increasing the productivities of the rural poor and integrating them into the commercial economy. The plan included a new set of policies which provided preferential assistance to small and medium size farms. Also, the plan provided for the reorganization of the agricultural public sector in order to increase its effectiveness and its unity of purpose in the implementation of sectoral investments.

The short-term goals, specified by the plan, reflect the added emphasis on the transformation of traditional agriculture:

(a) increasing agricultural output through increased production of foodstuffs, raw materials and export products, based on

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[5]The major sources consulted in the preparation of this section were: USAID [1970], BID-BIRF-AID [1977], and Hutchinson et al. [1974, Vol. 4].

special assistance to small and medium sized farmers;

(b) increasing agricultural employment through maximum use of labor whenever technologically feasible;

(c) gradual incorporation of subsistence producers into the market system; and

(d) strengthening future agricultural development prospects through the promotion of research, training and youth club programs.

The plan also gave the transformation of traditional agriculture a prominent place in the long term goals it set out:

(a) redistributions of agricultural incomes;

(b) reduction of regional disparities in agricultural development; and

(c) massive integration of the indigenous economy into the monetary economy.

The Rural Development Program made up about two-thirds of the Agricultural Development Plan and encompassed six distinct projects (Table 8). About 44 percent of the funding for the Program was provided by the Government of Guatemala; the remainder consisted of loans and grants, primarily from three international agencies. The United States Agency for International Development concentrated its support in those projects it had helped to develop--Basic Grains, Diversification, Human Resources and Artisanry--and provided about 51 percent of the funds required for their implementation. The International Development Bank and the Central American Bank for Economic Integration concentrated their financial support in the Land Tenure and Infrastructure projects of the program.

Table 8. Investments programmed for the agricultural sector by the National Development Plan 1971-75, Guatemala (million Quetzales)

Programs and Projects	Sources and amounts of funds			
	Government of Guatemala	USAID	Other international organizations	Total
Rural Development Program	42.5	25.0	31.5	101.7
Basic grains	4.1	8.1	--	12.2
Diversification	13.9	8.5	--	22.4
Human resources	3.1	5.6	--	8.7
Artisanry	0.6	0.8	--	1.4
Infrastructure	12.0	--	25.0	37.0
Land tenure	11.5	2.0	6.5	20.0
Remainder of agricultural sector	17.0	--	23.5	41.5
Livestock	4.5	--	13.5	18.0
Institute of marketing	3.5	--	3.9	7.0
Forestry	5.0	--	--	5.0
Other, including technical assistance	4.0	--	7.5	10.5
Total	62.2	25.0	55.0	143.2

SOURCE: Hutchinson et al. [1974, Vol. 4, p. 19].

With a large proportion of its population concentrated in the rural areas of the Highlands, where the possibilities for the expansion of the area under cultivation are low, the Government of Guatemala had two basic options to obtain the desired transformation of traditional agriculture. On one hand, it could do so in conjunction with efforts to redistribute land resources through colonization and land reform schemes. This means was the way in which the Land Tenure project of the program was to contribute to the attainment of the plan's goal. On the other hand, the thrust of the Rural Development Program was a second set of policies designed to transform the traditional economy through increases in productivity per hectare within the existing land tenure structure. Such was the basic feature of the five remaining projects of the program.

The USAID loan paper [USAID, 1970, Exhibit A] provided an account to justify the Basic Grains project. A comparison between the yield and costs of production for alternate levels of technology in the production of grains illustrated the potential gains attainable from inducing a traditional farmer to adopt modern agricultural practices and inputs. Results obtained from controlled experiments were impressive. Furthermore, evidence that highly profitable technologies were within the reach of Guatemalan farmers could be found in the high levels of productivity exhibited by the better farmers of the country. The absorption of an expanded grain production presented no problem within the national market, except for the wide fluctuations in prices which this market exhibited.

To take full advantage of this potential for increasing productivity per hectare, the Basic Grains project sought to introduce modern

practices in the production and marketing of five basic grains. Some Q12.2 million were to be spent over the plan's five year period in the modernization of: 10,000 hectares of beans in the Southeast; 6,000 hectares of wheat in the Highlands; 3,000 hectares of rice in the South Coast and the Northeast; 6,000 hectares of grain sorghum in the Southeast; and 35,000 hectares of corn throughout the country. The project strongly emphasized the introduction of improved seeds, and the use of fertilizers and pesticides on small and medium sized farms through the provision of production credit and technical assistance. To promote the attainment of the employment goals of the plan, the use of mechanization was to be de-emphasized. The project also included a provision to promote an increase in the efficiency of existing grain storage operations through an expansion in the private storage facilities and the provision of technical assistance in the marketing of grains [USAID, 1970, Exhibit A].

The potential for enhancing the value of production per hectare through agricultural diversification was also deemed high at the time the program was initiated. The diversity of climates which may be found within the country provided production possibilities of almost unlimited variety. The potential demand for high valued crops within Central America was estimated to be high and expanding, even though additional production and marketing efforts appeared to be required to tap it [USAID, 1970, Exhibit B].

In a manner similar to the Basic Grains project, the Diversification project also provided for the financing of credit and technical assistance. The Q22.4 million provided, however, aimed at the modernization and expansion of seven high valued non-traditional export crops.

While these diversified crops had not played a major role in Guatemala's economy, their promotion was seen as an opportunity to reduce the country's dependence upon its traditional exports while simultaneously increasing small farmers' income and employment. Accordingly, expansion and agricultural modernization on 37,000 hectares of land was sought. Vegetables, sesame, deciduous fruits, avocado and flowers were to be promoted, primarily in the Western Highlands and the South Coast; citrus and plantain production were to be promoted in the Northeast.

The Artisanry and Infrastructure projects were complementary to the two agricultural production projects in that they provided an alternate opportunity to obtain off-farm income or made agricultural activities more productive. The Artisanry project sought the modernization of handicrafts production and marketing activities, many of which are located in the Highlands, through the provision of technical assistance and credit. The Infrastructure project provided funding for the construction of access roads, grain storage and food processing centers and irrigation and drainage facilities, primarily servicing the target areas of the agricultural production projects.

The Human Resources project provided funding for the training of farmers, extension and credit agents and others who provide services to the agricultural sector. The project sought to strengthen the new public service institutions that were to be organized by the plan.

The reorganization of public agencies, that provide services to agriculture within an integrated "Sector Público Agrícola" (agricultural public sector) structure, constituted the plan's second major feature of significance for the transformation of Guatemala's traditional agriculture.

A 1969 study had identified the following weaknesses in the services provided to the sector: a dozen or so extension services operated without unity of purpose or coordination of activities; there was duplication in existing programs of research in agriculture; and there existed unnecessary rivalry and duplication of services among public credit agencies [USAID, 1970, p. 54]. The reorganization which took effect between 1971 and 1973 responded to these deficiencies by strengthening the public sector's ability to provide effective services to small and medium income farmers and by granting decentralized operational authority to specialized service agencies while simultaneously consolidating planning and coordinating activities within the Ministry of Agriculture.

All public activities servicing the agricultural sector were assigned to five operational agencies. Under this new arrangement, the General Directorate for Agricultural Services (DIGESA) remained as an operational agency of the Ministry of Agriculture and was given responsibility over all extension service activities. The other four operational agencies were granted a semi-autonomous status whereby their boards of directors were to have many members in common and the Ministry of Agriculture would preside over each agency. Under this arrangement, DIGESA's farmer production research responsibilities were entrusted to a new agency: the Agricultural Science and Technology Institute (ICTA). The Ministry's former Marketing Directorate and the grain price stabilization unit of the former National Production Institute were merged to create a National Agricultural Marketing Institute (INDECA) responsible for the provision of technical assistance in the marketing of agricultural products and for the stabilization of agricultural prices.

Similarly, the equity capital and credit activities of the Ministry's National Institute for Stimulating Production (INFOP), of the Inter-american Supervised Credit Cooperative Service (SCICAS), and of the semi-autonomous National Agricultural Bank (BNA) were fused to create the Agricultural Development Bank (BANDESA). All land colonization and distribution activities were kept under the purview of the National Agricultural Transformation Institute (INTA).

The System

Since BANDESA began to operate in May 1971, it has managed two distinct loan programs. One program is a commercial operation dependent upon ordinary lending and borrowing procedures subject to the regulations of the national banking system. The second program is a Trust Fund account in which the agency acts as a contractor for the government in the financing of loans to small and medium sized farmers who, ordinarily, would not qualify for a commercial loan. On December 31, 1974, about 42 percent of BANDESA's Trust Fund account was made up of capital transferred from the borrower SCICAS operation. Evenly divided between USAID and government contributions, capital provided in support for the Rural Development Program amounted to Q11.6 million or about 38 percent of the Trust Fund account. The remaining capital in the account had been provided by other international agencies, the Guatemalan government and earnings from loan operations [BID-BIRF-AID, 1977, Annex 12, pp. 12-13].

As a result of the restructuring of the agricultural public sector and the adoption of the Rural Development project, a system for the granting of credit to small and medium sized farmers for the production

of grains and diversified crops was instituted. A basic feature of the system was its reliance upon BANDESA agents for the administrative management of loans and upon DIGESA promoters for the technical monitoring of the use made of loan funds. For purposes of the present study, this system is regarded as the Supervised Credit System of Guatemala (SCSG).

Initial Rural Development Program's financing of the SCSG for the 1971-1975 period amounted to Q28.9 million. About three-fourths of the fund were destined to promote modernized crop diversification and the rest was allocated for upgrading the productivity of basic grains production (Table 9).

As the program developed, a substantial proportion of the funds originally allocated to support grain marketing activities was redirected to finance credit operations. Also, the government shifted to a much greater emphasis upon the promotion of basic grains. Producer interest in agricultural diversification proved to be smaller than was anticipated. Perhaps most importantly, substantial increases in grain prices reached crisis levels in rural areas where the population heavily depended on these grains for their livelihood. For 1975, BANDESA's provisional budget anticipated total Basic Grains loans amounting to Q4,677,000 compared to a total amount for Diversification loans of Q5,797,000 [BID-BIRF-AID, 1977, Annex 12, Annex Table No. 8].

The SCSG was instituted in response to two factors identified as major constraints upon the Guatemalan small farmer's potential for attaining high levels of productivity [USAID, 1970, Exhibit A, p. 11]. First, a lack of capital with which to purchase high cost modern inputs was cited as a factor preventing the small farmer from taking full

Table 9. Programmed distribution of funds for the Supervised Credit System, Guatemala, 1971-1975

	Credit		Technical Assistance		Total	
	Million dollars	Percent	Million dollars	Percent	Million dollars	Percent
Basic grains	4.04	19.1	2.42	31.2	6.5	24
Diversification	17.13	80.9	5.34	68.8	22.4	77
TOTAL	21.17	100.0	7.76	100.0	28.9	100

advantage of readily available technological innovations or from producing highly profitable crops. His difficulties were enlarged by the inadequacies of existing institutions in making rural credit accessible to him. Secondly, the paucity with which technological innovations and results from agricultural experimentation reached a large number of small farmers was also seen as limiting his possibilities for modernizing his agricultural practices.

A preoccupation with making credit accessible to small farmers was an important feature characteristic of the SCSG. A BANDESA-DIGESA instructive, dated September 17, 1971 [annexed to Patterson et al., 1972], indicated that, for the purpose of granting a loan, a farmer was to be considered small or medium sized if his working capital did not exceed Q40,000 or his cash on hand did not exceed Q20,000. In a similar vien, for purposes of the Rural Development Plan, the small to medium sized farm would be included within the range of farmers with 3 to 28 hectares in a crop with low value, such as corn, and to farmers with 0.2 to 0.5 hectares in high valued crops, such as flowers (Table 10).

The coordination of activities between BANDESA credit agents and DIGESA promoters or extension agents was a second important feature of the SCSG. If the credit funds provided were to be effective in the modernization of production practices, an efficient system for the transferring of technological innovations had to be coordinated with the granting of loans. While no dependency relationship existed between the DIGESA promoters and the BANDESA agent, both were considered to be credit agents of BANDESA and an integral part of the agricultural public sector. The specific responsibilities of the DIGESA promoters were: (a) to identify possible subjects of credit on the basis of farm size,

Table 10. Range in area that was used to define small to medium sized farmers for the purpose of the Rural Development Plan

Crop	Hectares
Corn	3 - 28
Beans	2 - 15
Rice	2 - 25
Sorghum	3 - 25
Wheat	0.5 - 10
Sesame	2 - 15
Citrus	2 - 10
Avocado	2 - 10
Deciduous fruits	0.3 - 7
Plantain	2 - 15
Bananas	2 - 15
Vegetables	0.3 - 7
Flowers	0.2 - 0.5

SOURCE: Circular BANDESA-DIGESA No. 1, p. 2, annexed to Patterson et al. [1972].

interest in cultivating crops for which the regional agency of BANDESA was providing credit and other personal characteristics; (b) to draw up farm work plans and fill out credit applications for those farmers deemed credit worthy by the BANDESA agents; (c) to report regularly on the progress being made by the farmers to ensure that actions were in accordance with the approved work plan, and to make recommendations for future fund disbursements; and (d) to provide technical orientation to the farmer whenever this was necessary to ensure the rational use of credit funds. BANDESA agents, on the other hand, were charged with the following responsibilities: (a) select, among interested farmers, those who were credit worthy; (b) review and approve or disapprove credit applications; (c) make disbursements as called for by the work plan in the form of cash or chit to the farmer or an input supplier; (d) monitor and report on the financial progress of loans, with authority for stopping disbursements or granting repayment deferments whenever warranted [USAID, 1970, and Circular BANDESA-DIGESA N^{o} 1 annexed to Patterson et al., 1972]. Other features characterizing the SCSG referred to the terms and procedures of the loans.

Loans were granted to farmers on a specific crop basis rather than to the farm as a unit [Hutchinson et al., 1974, Vol. 4, p. 37]. In most instances, 100 percent of the costs of production of a given crop were covered by the loan [BID-BIRF-AID, 1977, Annex 12, p. 41].

Interest rates on all BANDESA loans were subsidized. In 1975, Trust Fund loans to finance crop diversification carried an interest rate of 8 percent. Basic Grain loans were provided at 5 percent interest. These rates contrast sharply with prevailing commercial bank rates of about 12 percent [BID-BIRF-AID, 1977, Annex 12, p. 21].

The length of the loan period varied by crop. Since the large majority of crops financed had a yearly production cycle, most loans had a duration of less than 12 months. The proportions of BANDESA Trust Fund agricultural loans granted in 1972, 1973 and 1974 with repayment terms longer than 12 months were equal to 7.1, 6.7 and 2.8 percent, respectively [BID-BIRF-AID, 1977, Annex 12, pp. 21-23].

In an attempt to ensure that the credit was used for the intended purposes, credit for seeds, fertilizer and pesticides was provided in kind, and distributed through credit chits, rather than in cash. This practice was, in fact, widespread in basic grains, particularly corn, where fertilizer and seed inputs accounted for a large proportion of purchased inputs.

Appraisals of the System's Performance

There is widespread agreement regarding some of the accomplishments of Guatemala's National Development Plan of 1971-1975. The reorganization and strengthening of public agencies servicing the agricultural sector is often regarded as an important accomplishment of the plan.[6] Government expenditures in agriculture also increased as a result of the plan. For the period 1968-1970, combined capital and current public expenditures for agricultural services accounted for an average of about 3.7 percent of all public expenditures. For the period 1971-1976 the comparable proportion was 4.6 percent.[7]

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[6] See, for example, USAID [1977, pp. 3, 8], World Bank [1978, p. 74], BID-BIRF-AID [1977, pp. 22-23] and USAID [1975, Exhibit 1].

[7] Calculated from Ministry of Finance figures reported in World Bank [1978, Statistical Annex, Tables 5.2 and 5.3].

Moreover, a large proportion of these added expenditures went to service small farmer needs. Between 1971 and 1975 the number of extension agents increased from 94 to 450. The number of small farmers who received production credit on high valued crops and basic grains is estimated to have increased from 2,000 in 1971 to about 14,000 in 1974 [USAID, 1975, Exhibit 1, p. 5].

Available evidence is inconclusive regarding the extent to which the plan made significant headway in transforming traditional agriculture. Specifically, the extent to which the plan and subsequent related efforts increased agricultural incomes and employment among the Guatemalan rural poor is still unclear [Hutchinson et al., 1974, Vol. 4, p. 7].

The Guatemala Farm Policy Analysis[8] [Daines, 1975a] constitutes the most comprehensive appraisal of the SCSG to date. Based on data from the Small Farmer BANDESA Credit Survey, the analysis compared the performance of 800 matched pairs of BANDESA credit clients and non-BANDESA small farmers in an attempt to determine the impact of credit upon production performance. The major conclusions of the study are the following:

1. (a) Credit appears to have a significant impact upon output performance of farmers. The major factor underlying this increased output performance of BANDESA farmers appears to be their ability to make an increased use of land. These differences consist partly of an area expansion effect obtained through the purchase and rental of additional farm land and partly as the result of an intensification effect obtained through multiple cropping, interplanting or by dedicating a larger proportion of the land on farms to productive activities

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[8] Throughout the present study the Guatemala Farm Policy Analysis is labeled in abbreviated form as GFPA.

(b) From a policy standpoint, this finding lends support to land redistribution programs.

2. (a) The most significant differences in the output performance between credit and non-credit farms were detected among farms with less than one hectare of land. The major factor explaining the apparent advantage of BANDESA farmers among this group at the lowest end of the income scale was the higher value of their crop mix.

   (b) This finding lends support to added emphasis on crop diversification.

3. (a) Credit does not appear to have had a significant impact upon yields.

   (b) Together with the previously mentioned findings on crop mix, the minor role of yield increases upon output performance suggests that research and technical assistance efforts should be redirected to encourage farmers to shift to higher valued crops.

4. (a) Technical assistance appears to have had an impact upon output, but not the intended one through increases in yields. Furthermore, tentative comparisons on farm output performance suggest that the linking of credit and technical assistance provides no additional advantage.

   (b) The emphasis on combining credit with technical assistance of supervised credit programs may be unfounded. It may be cheapest and most effective to provide credit untied to technical assistance.

5. (a) The lowest income BANDESA farms in the poorest regions showed a significant net income superiority over their non-BANDESA counterparts.

   (b) Thus, the provision of credit in Guatemala should, from an output performance as well as an equity standpoint, be concentrated in the poorest regions of the country.

6. (a) Credit appears to have had a positive effect upon employment generation. This positive employment effect of credit is primarily due to differences in the labor requirements of crops cultivated by the credit and non-credit groups.

   (b) Once again, efforts are best redirected to promote crop diversification.

Of the above set of conclusions from the GFPA, Proposition 1 has been easily accepted [USAID, 1977, Attachment I, p. 2; USAID, 1975, Exhibit 1, pp. 13-14]. In effect, the finding that credit had its most significant impact through increases in land utilization has been used in support for the added emphasis which the National Development Plan 1975-1979 and related U.S. capital assistance [USAID, 1975] have given to colonization programs.

A complete discussion of the merits of programs which seek to improve the welfare of the rural poor of Guatemala by providing small and landless farmworkers--particularly those of the densely populated Highlands--with increased access to land resources is beyond the scope of the present study. It is important to understand, however, that there are serious political and economic obstacles which need to be overcome for such a strategy to be successful. Given the effective occupation of the fertile lands of the Pacific Coast and the high level of productivity of the agriculture which has been established there, land reform in such a region would tend to be very costly in terms of the temporary but significant reductions in agricultural production which would result as adjustment to the new patterns of tenure occurs, and, also, in terms of the social unrest which would undoubtedly accompany the redistribution of land and wealth. On the other hand, economically profitable levels of agricultural productivity in the yet unsettled tropical lowlands of the Franja Transversal Norte or the Peten do not appear to be sustainable for long periods under known intensive agricultural practices.

It should also be noted that not all tropical lands are unresponsive to intensive land use practices nor do they pose the same

environmental problems. Alluvial soils in the tropics tend to be quite fertile and may sustain intensive agriculture over many years with only a gradual loss in productivity. Most of the yet unsettled tropical lowlands of Guatemala, however, have low fertility soils and are ecologically very fragile.

In addition, the infrastructural investments required to effectively settle these lands tend to be quite large.[9] Furthermore, the distribution of unsettled lands may pose political problems which may be as thorny as those associated with land reform programs. For instance, there are indications that speculation over the frontier lands of the Franja Transversal began immediately after the prospects of infrastructural development were announced and continued to raise the price of these lands throughout the period in which the National Congress debated the merits of the colonization project. The increased cost of project implementation to the public sector will most likely prevent the full benefits of colonization from reaching the rural poor.[10] Finally, it should be noted that making it profitable for farmers to expand their output through an increase in the intensity of land use facilitated by a subsidized credit program will not necessarily be advantageous to the general economy. This is particularly true when this increase in the use of land occurs in an area like Guatemala's Central Highlands, where arable land is extremely limited and where, consequently, increasing use of land by one group of farmers may come at the expense of their bidding

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[9] Nelson [1973] provides a well documented account of the poor record of public attempts to colonize the humid tropics of Latin America.

[10] For a description of the Franja Transversal project see USAID [1975].

away land from another group or it may come from a more intensive use of soils that are highly susceptible to erosion.

Accordingly, a complete appraisal of the impact of the SCSG would focus on a complete measure of output which would consider not only the direct impact upon the output of farmers brought about by credit, but it would also try to measure any output foregone that accompanies shifts in resource use. In principle, differences in the net incomes of BANDESA and non-BANDESA farmers would constitute a better measure of the extent to which the SCSG advanced the goals of the Rural Development Program. In effect, proposition number 5 above is based on this kind of comparison. But, aside from the fact that a statistically significant net income advantage of BANDESA farmers over non-BANDESA was not observed in all regions or for all farm sizes, the actual measure of net income employed in the comparison was not an appropriate one. For instance, BANDESA farmers derived less of their income from off-farm work than non-BANDESA farmers [Daines, 1975a, p. 49], which suggests that the opportunity cost of unpaid family labor may have been greater than zero. In the calculations of net farmer income, carried out by the GFPA, however, unpaid family labor was not subtracted as a cost of production [Daines, 1975a, p. 107]. Perhaps most importantly, no attempt was made to measure the income foregone by making credit available at subsidized prices.

Propositions 2 and 6 above have received some attention in the literature. Emphasis has been placed on the fact that, while differences in crop mix may be said to be associated with availability of credit, this is not the same as saying that they were caused by credit availability [USAID, 1975, Exhibit 1, p. 4]. This comment is

particularly pertinent. The matching of sample pairs according to the crop composition, which BANDESA farmers had prior to credit, was done only for a few subclasses of farms [Daines, 1975a, p. 124]. Yet, the procedures for selecting farmers to participate in the credit program described in the previous section would suggest that, among all BANDESA farmers, those with high valued crops would tend to be concentrated in the group of smallest farms--i.e., those with one hectare or less--whereas those with basic grains would tend to be concentrated in the larger farm size groups.

From a policy perspective the recommendation that Guatemala specialize in the production of high valued labor intensive crops is a wise one given the country's resource endowment. Experience with the Diversification project of the Rural Development Program suggests that marketing costs stand in the way of significantly altering the crop mix of traditional farmers, at least within short policy horizons. Evidence suggests that as the Guatemalan farmer is provided with additional land and income, he shifts from producing basic grain to producing commercial high valued crops [Alvarez, 1977]. Accordingly, one sensible strategy to produce crop diversification in Guatemala could be based on increasing small farmer's income and resources through increases in yield on those crops with which he is familiar--basic grains.

The technical upgrading of crop production techniques was at the heart of the agricultural transformation efforts of the National Development Plan 1971-75. To find that credit did not produce increases in yields (see proposition 4 above) was completely contrary to expectations. Combined with the already mentioned doubts as to the extent to which increases in land use and shifts in crop mix indeed produced increases

in net incomes, such a finding casts doubts on the SCSG's impact upon the plan's objective of improving small farmers' incomes. Moreover, the finding, even if tentative, that the combination effect of technical assistance and credit had no significant effect upon output per hectare, casts doubt on a basic feature of the SCSG.

Scope and Objectives of the Present Study

A major immediate objective of the SCSG was that of increasing yields in the production of specific crops. If such yield increases did not come about, it is important for the sake of future program design to understand where the SCSG failed.

A full appraisal of the performance of the SCSG requires that the role played by production credit and technical assistance in promoting efficient agricultural practices be clarified. The present study addresses this issue by examining SCSG performance within the context of a specific crop, namely corn. The data used for the analysis is that provided by the Small Farmer BANDESA Credit Survey.

Small Farmer BANDESA Credit Survey (SFBCS)

The survey's main objective was to provide reliable information which could be used to assess the impact of BANDESA's credit program. Farm management data were obtained on a matched-paired set of 800 BANDESA credit clients and 800 homologous non-BANDESA farms. The total number of complete and edited questionnaires in the sample is 1,548.

Interviews were conducted in 1974 and the data cover the 1973 calendar year. It should be noted that 1973 was an exceptionally good year from the standpoint of corn productivity in Guatemala. Average

annual corn yields for the period 1970-1972 and 1974-1976 were 1190 kg/ha and 1304 kg/ha, respectively. In contrast, corn yields were 1672 kg/ha in 1973 [World Bank, 1978, Statistical Annex, Table 8.2]. Any apparent deficiencies in yield response to modern agricultural practices should not be imputed to poor weather conditions during the period covered by the survey.

BANDESA loan holders constitute a rather special group in that they are small and medium sized farmers who were identified by DIGESA promoters and BANDESA agents as credit worthy. Out of this set of about 6,000 loan holders, 800 were selected in a stratified random sampling procedure which ensured that the major regions and important crops in these regions had sufficient representation to allow reliable statistical inference concerning these two variables. During the early stages of the sampling procedure, DIGESA promoters were asked to make about 15 matches each, by selecting a non-BANDESA farmer from his area with characteristics similar to those of each of a BANDESA subset of about 3,000 farmers. In principle, this control group of non-BANDESA farmers would be identical to the BANDESA set prior to having received credit. The characteristics which promoters were asked to match were farmer's age, size of farm and crop composition. In practice, the matching procedure ran into difficulties. Often interviewers were unable to find the selected non-BANDESA farmer and had to identify an alternative. Nevertheless, subsequent review of the data shows that the two groups are similar in terms of non-credit related characteristics such as farmer age, education level, family size and distance to market.[11]

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[11]For a more detailed description of the data, survey design and procedure, see Daines [1975a, Appendix C], Robertson et al. [1975] and O'Quinn et al. [1975].

Unfortunately, the information matching BANDESA and non-BANDESA pairs of observation was not preserved for use in statistical analysis. The available data are a random sample of BANDESA credit farms and a sample of non-BANDESA farms which by design was selected to be dependent upon the credit sample. The important question is the extent to which there is empirically a paired dependence between the two samples. In practice such pairing is rarely effectively carried out, and in this case, interviewers revealed such difficulty. To the extent that there is a pairwise dependence between the two samples, the reported tests and parameter estimates will be less than efficient, and in some instances, tests may be biased. Where pertinent, specific cautionary remarks are included throughout the report.

Focus on Corn Production

The SCSG treated the production of specific enterprises in a compartmentalized fashion with little regard for other aspects of a farmer's operation. This rather limited approach to small farmer assistance permits an operationally simple measure of the success or failure of a particular aspect of the SCSG. By focusing the analysis on intended effects upon specific crops, it is possible to avoid some of the pitfalls associated with interpreting behavioral differences in crop composition between credit and non-credit farmers as credit induced changes. Though occasionally something will be said with regard to other crops, for the most part, the focus of the present study is placed on the production of corn.[12]

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[12] Bardhan [1973] also focuses on the production of a single agricultural enterprise in the analysis of farmers' productive behavior.

From the Small Farmer BANDESA Credit Survey, those farmers who produced corn non-interplanted with any other crop have been selected for analysis. It is implicitly assumed that the productivity of resources in corn production is independent of the level of production of the other enterprises of the farmer. It should be noted, however, that this assumption may be violated in a few sample cases where crop rotation is practiced to sustain soil fertility, or where corn is cultivated as a second crop of low productivity in a given plot during the year.[13]

One advantage of focusing on corn is the importance of the crop and the relatively large number of farms on which its cultivation is practiced (Table 11). The number of farms in the sample was 1,548 and corn was cultivated on 1,118 of them. In contrast, beans, the second most popular crop, was cultivated on only 305 farms.

That corn should be singled out for study is particularly pertinent on account of the crop's relevance to traditional agriculture. Though corn cultivation is widespread throughout the country, it is of utmost economic relevance to the smallest and poorest farms. As may be seen from Table 12, the proportion of land used for corn cultivation varies with farm size among sample farms in which non-interplanted corn was grown.

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[13]For a discussion of specification and estimation of production relationships when the productivity of resources of one enterprise is dependent upon the production of other enterprises, see Mundlak [1964], Mundlak and Razin [1971] and Vinod [1968].

Table 11. Rank of crops by number of farmers in sample who grew the crop[a]

Rank	Crop	Number of observations	Rank	Crop	Number of observations
1	Corn	1118	31	Watermelon	5
2	Beans	305	32	Melon	5
3	Wheat	230	33	Peaches	4
4	Sesame	161	34	Oats	3
5	Sorghum	154	35	Tomatoes, cherry	3
6	Tomato	143	36	Flowers	3
7	Rice	127	37	Avocado	3
8	Coffee	74	38	Pepper, red	3
9	Potato	53	39	Fruit	3
10	Onion	41	40	Strawberry	2
11	Oranges	40	41	Cauliflower	2
12	Plantain	40	42	Squash	2
13	Sugarcane	30	43	Pears	2
14	Beans, broad	22	44	Cardamon	2
15	Tobacco	22	45	Cocoa	2
16	Garlic	19	46	Pepper, large	2
17	Carrots	16	47	Pumpkin seeds	1
18	Pasture	15	48	Lettuce	1
19	Pepper, black	14	49	Radish	1
20	Apples	14	50	Chickpea	1
21	Pineapple	13	51	Vegetables	1
22	Cabbage	11	52	Lime	1
23	Beets	11	53	Copalpom	1
24	Peanuts	10	54	Watercress	1
25	Cucumber	9	55	Maguey	1
26	Pepper, hot	9	56	Pacaya	1
27	Guisquil	9	57	Banana	1
28	Yuca	9	58	Papaya	1
29	Mango	8	59	Coco	1
30	Peas	7	60	Passion fruit	1

[a]There are four other crops for which no observations are available: forest, mandarin, cotton and soybean; total number of farmers in sample is 1548.

SOURCE: SFBCS

Table 12. Ratio of corn area under production to arable land on farms which grew non-interplanted corn, by farm size

Farm size (hectares)	Ratio
0 - 1	0.678
1 - 3	0.680
3 - 5	0.547
5 - 10	0.581
10 - 20	0.460
20 - 50	0.376
50 - 100	0.337
Over 100	0.126
All sizes	0.573

SOURCE: SFBCS.

Objectives

On the basis of the evidence available from the Small Farmer BANDESA Credit Survey and with a focus on the production of non-interplanted corn, the objectives of the present study are to determine the extent to which BANDESA's credit and DIGESA's technical assistance were effective in (a) inducing farmers to use modern inputs such as improved seeds, fertilizers, pesticides and machinery, and (b) assisting farmers in making effective use of the chosen technology.

Organization of the Dissertation

In Chapter II the theoretical underpinnings which guide subsequent statistical analysis are presented. In Chapter III the evidence on yield differences by credit group is reviewed. The impact which the SCSG had on modern input adoption and production efficiency is examined in Chapters IV and V, respectively. Chapter VI contains a summary of the results and recommendations.

CHAPTER II
ANALYTICAL FRAMEWORK

Though not always made explicit, programs which seek to promote the widespread adoption of technological innovations often view the target community as one in disequilibrium. The objective is to move these farmers who have not adopted the new technology toward the higher income equilibrium by inducing them to adopt the use of the new technology. The present chapter begins with a brief sketch of this view as an introduction to the roles which credit and technical assistance are supposed to play in expediting the process of technological innovation. A basic model of individual farmer choice between technologies is presented in the first section. This permits a more rigorous statement of the roles which the SCSG assigned to credit and technical assistance in the second and third sections, respectively.

Singh described the process of technological innovation transfer in terms of a three-phased scenario.[1] During a first phase, farmers practice a traditional agriculture, profitable investment opportunities are limited, savings are low and credit markets oligopolistic and fragmented. During a second phase, farmers gradually become aware of profitable technological innovations, and high rates of return to investments increase the effective demand for capital resources.

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[1] The brief description presented here follows that provided in Donald [1976, pp. 219-222]. See also USAID [1972, Vol. XIX, p. 421].

Duality in agriculture emerges as savings lag and as some farmers still are unfamiliar with the new technology. Input, output and capital markets develop slowly. During phase III, a new high income equilibrium prevails. A shift back toward current consumption occurs as profit opportunities become limited again. But, the higher incomes attained provide for a savings level sufficient to sustain a more competitive capital market responsive to any new profit opportunities.

Singh's prescription for the role to be played by institutional credit programs during each phase is also noteworthy. During the first phase the provision of limited amounts of institutional credit could benefit some farmers through lower interest rates and the break-up of some oligopolistic holds on capital markets. But, limited investment opportunities and low rates of return on capital could lead to widespread loan default rather than to increases in production and incomes if a major institutional credit program were mounted. Rapid increases in the demand for credit during the second phase could lead to very high interest rates becoming a barrier to further adoption of innovations. By preventing these unduly sharp increases in interest rates, institutional credit could expedite the adoption process during this phase. The increased levels of commerce during phase III would keep the demand for financial resources widespread, relatively higher and interest inelastic. The availability of institutional credit funds should be reduced and, instead, public programs would do best to concentrate on stimulating the mobilization of household savings.

The provision of technical assistance is also likely to be most effective during the second phase of the technological innovation process. During the first and third phases, an extension agent may

improve a farmer's productivity somewhat by teaching him some new practices which do not constitute a major departure from the technology with which the farmer is already familiar. But, the returns to technical assistance programs will be highest during a second phase in which extension agents serve as (a) providers of information on the existence of a technology and (b) teachers of how that technology should be used to provide highest returns to the farmers.

The identification of the stage in which a community finds itself is clearly an important issue. When does a technological innovation constitute a significant departure from the traditional technology sufficient to warrant the mounting of major efforts to expedite the process of adjustment? How large should these efforts be and what should they encompass? In the following sections the answers implicit in the formation of the SCSG are examined and presented in terms of hypotheses to be tested in subsequent chapters.

The Basic Model

Consider a farmer who has to choose between two technologies; one, $f(\cdot)$, in which production is a function of a composite set of traditional inputs, x_1, and a modern technology, $g(\cdot,\cdot)$, which employs modern inputs, x_2, in addition to traditional ones. For given product and factor prices, p, p_1, p_2, the farmer's unconstrained profit maximization problem may be specified as

$$\text{Max } \pi = \pi_1 z + \pi_2(1 - z) \tag{1}$$

where:

$$z = 0,\ 1$$

$$\pi_1 = pf(x_1) - p_1x_1$$

$$\pi_2 = pg(x_1, x_2) - p_1x_1 - p_2x_2$$

That is, profits may be expressed as a function of a dichotomous choice option whereby a farmer selects between a modern and a traditional technology according to which one yields him more profits. The solution value for z determining a farmer's choice of technology, clearly depends on whether, for admissible values of x_1 and x_2, π_1 is greater or less than π_2.

Consider the optimal levels of use of x_1 within the options which the traditional technology offers, and optimal levels of x_1 and x_2 within the options which the modern technology offers. These within-technology optima may be found for the traditional technology by solving for x_1 in

$$\text{Max } \pi_1 = pf(x_1) - p_1x_1 \tag{2a}$$

and are given by the first order condition:

$$pf_1(x_1) = p_1 \tag{3a}$$

where $f_1(x_1) = \frac{df}{dx_1}$. Second order conditions ensure a maximum:

$$\frac{d^2f}{dx_1^2} = f_{11}(x_1) \leq 0. \tag{4a}$$

Within-technology optimal values of x_1 and x_2 for the modern technology are obtained as the solution to the problem

$$\text{Max } \pi_2 = pg(x_1, x_2) - p_1x_1 - p_2x_2 \tag{2b}$$

provided by the first order conditions:

$$pg_1(x_1, x_2) - p_1 = 0 \tag{3b}$$
$$pg_2(x_1, x_2) - p_2 = 0$$

where $\frac{\partial g}{\partial x_i} = g_i$, i = 1, 2. Second order conditions ensure a maximum:

$$pg_{11} - 1 < 0 \quad \text{and} \quad (pg_{11} - 1)(pg_{22} - 1) - p^2 g_{21} g_{12} > 0 \tag{4b}$$

Let π_1^* and π_2^* denote the optimal levels of profit obtained as solutions to the within-technology maximization problems (2a) and (2b), respectively. The values, which π_1^* and π_2^* will take, depend upon the particular set of product and factor prices prevailing. For some forms of $f(\cdot)$ and $g(\cdot,\cdot)$ it is quite possible for $\pi_1^* > \pi_2^*$ for a specific set of values of p, p_1, p_2, and for $\pi_1^* < \pi_2^*$ for an alternate set. Much of the induced innovation literature focuses on the role which a country's relative factor prices have in shaping modern technologies; i.e., in shaping $g(\cdot, \cdot)$ [Binswanger, 1974; Hayami and Ruttan, 1970].

To fix ideas, consider a limited range of variation for product and factor prices over which a single inequality relationship between π_1^* and π_2^* holds. Over short and medium term horizons, such an assumption is reasonable within a given country. In the absence of institutional intervention in the market, the relative factor endowments and demand patterns underlying relative prices tend to change only gradually with time. Accordingly, a condition necessary to make a modern technology attractive to a farmer is that it be "potentially profitable"; i.e., that

$$\pi_2^* > \pi_1^* \tag{5}$$

If (5) holds true, why would a farmer opt for a traditional technology? Underlying the creation of the SCSG was a twofold answer. First, the farmer is constrained by his limited capital resources and by the high working capital requirements of the modern technologies for which he could opt, hence the rationale behind the granting of production credit. Secondly, the farmer is unfamiliar with the effective use of modern technologies. Hence, the rationale behind the tying of technical assistance to the provision of credit. The implications of this rationalization of the SCSG may be examined within the context of the farmer's profit maximization problem embodied in (1).

Credit

Effect upon Modern Input Adoption

Adams [1971, p. 167] has questioned the need to provide credit as a means to induce farmers to adopt modern technologies: "Do farmers need to be bribed to do something that is supposed to be profitable?" In a similar vien, Tinnermeier [reported in Donald, 1976, p. 37] has stated that ". . . to assume without examination that new technology is available for the small farmer, and that it is profitable to him, is the biggest error the proponents of agricultural credit have made."

Here a distinction between a potentially profitable technology and the actual returns its use brings under specific circumstances is useful. There are plausible conditions under which a farmer with a limited amount of capital will find it to be more profitable to use a traditional technology than a modern one, even if the latter is potentially

profitable. In the Guatemalan setting this could be the case if, for instance, improved varieties of corn were unresponsive to small dosages of fertilization, but highly responsive to large dosages. A farmer's capital limitations and the high relative cost of fertilizers could prevent him from purchasing this input in the amounts which bring about high marginal productivity. Table 13 illustrates a specific set of conditions, among the many possible, under which a capital limitation might prevent a farmer from adopting a potentially profitable modern technology. The implications of alternative profit maximization problems are presented there, for specific forms of one and two input transcendental production functions which exhibit the three stages of the neoclassical input-output relationships [Halter et al., 1957].

A rather simplistic view of the farmer's options would suggest that his capital constraint is a rigid one. The solution to the profit maximization problem embodied in (1) would be required to satisfy a constraint such as:

$$p_1x_1z + (p_2x_2 + p_1x_1)(1 - z) \leq C \qquad (6)$$

where C is the fixed amount of capital at the farmer's disposal.[2] The second and sixth columns of Table 13 illustrate the implications for the use of inputs and profits of the imposition of a rigid constraint fixed at 1.96 units of capital. With such a restriction the use of the potentially profitable modern technology would bring about a net income

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[2]Care should be exercised in interpreting the use of the term capital in the present context. The term is used here as synonymous with working capital or cash funds, rather than as a physical factor directly affecting production processes. In equation (6) a farmer's capital endowment is given by C. He may use C to purchase x_1 and/or x_2, which may be land, labor or a physical capital input such as a tractor.

Table 13. Illustration of possible implications for expected profits from the use of traditional versus modern technologies under alternative capital constraints

Item	$p = 0.1$		$p_1 = 0.5$				$p_2 = 6$	
	$y = f(x_1) = 6x_1^4 e^{-.9x_1}$				$y = g(x_1,x_2) = 6x_1^4 x_2^4 e^{-.9x_1 - .9x_2}$			
	π^*	$C \leq 1.96$	$r = 0.15$		π^*	$C \leq 1.96$	$r = 0.15$	
			0.15B	0.15(B + C)			0.15B	0.15(B + C)
x_1	3.92	3.92	3.85	3.85	4.36	1.61	3.47	3.47
x_2	--	--	--	--	3.59	0.19	4.34	4.34
π	2.20	2.20	2.20	1.91	4.40	-1.93	0.90	1.19
$x_1p_1 + x_2p_2$	1.96	1.96	2.21	2.21	23.73	1.96	26.44	26.44
Amount of capital priced at r	0	0	0.25	2.21	0	0	26.44	24.48
$\frac{y}{x_1}$	9.41	9.41	10.71	10.71	64.51	0.006	78.78	78.78

loss to a farmer. He would clearly opt for the traditional technology, which in this case would bring him a positive profit of 2.2 units.

In the real world, capital limitations are not so rigid. As Adams [1978, p. 547] forcefully argues, ". . . substantial voluntary rural savings capacities exist." And, even the poorest farmers often resort to borrowing from relatives or other informal capital market mechanisms whenever profitable opportunities arise. Accordingly, a more realistic capital constraint which must be satisfied by a profit maximizing farmer would be

$$p_1x_1z + (p_2x_2 + p_1x_1)(1 - z) \leq C + B \tag{7}$$

and a farmer's profits would now consist of

$$\pi = \pi_1 z + \pi_2(1 - z) - rB \tag{8}$$

where B is the amount of borrowed funds and r is the price to be paid for their use. Columns 3 and 7 of Table 13 trace the effects of such a situation for a farmer with 1.96 units of own capital and the ability to borrow at an interest rate of 15 percent over the production period. Though profits from the use of the modern technology would be positive, it would still not pay the farmer to abandon his traditional and more profitable ways.

If informal capital markets enable the farmer to borrow at a rate of, say, 15 percent, it would be reasonable to suggest that he may lend his own capital through the same informal capital market mechanism at a similar rate. If such a view is adopted, then a farmer's profit maximization problem would be restated as

$$\text{Max } \pi = \pi_1 z + \pi_2(1 - z) - r(C + B)$$

with $(C + B) = p_1x_1 + p_2x_2$, and first order conditions for a maximization would become

$$py - p_i(1 + r) = 0 \qquad \begin{array}{l} i = 1,\ y = f(x_1) \text{ if } z = 1 \\ i = 1, 2,\ y = g(x_1, x_2) \text{ if } z = 0 \end{array}$$

Once again, for the illustrative situation of Table 13, the traditional technology would be more profitable than the potentially profitable modern technology.

Whether the opportunity cost of own-capital is or is not equal to the interest rate at which a farmer of a traditional rural community of Guatemala may borrow, it is clear that with credit available at sufficiently low rates of interest, a potentially profitable technology which makes use of modern inputs will, in effect, become a profitable and attractive option to the farmer.

Aside from the theoretical merits underlying the granting of credit to small farmers, in practice the SCSG went beyond this simple proposition and into the supervision of the uses of credit funds. Production plans were drawn up to suit the individual farmers receiving credit, chits for the purchase of selected inputs were often used in lieu of cash, and systems for monitoring farmer compliance with the original work plans were devised. Notwithstanding these efforts, the fact is that the yields of BANDESA credit farmers failed to be much greater than those of non-BANDESA farmers. Accordingly, the first hypothesis to be tested regarding the effectiveness of the SCSG is then

H1: Credit was not a factor inducing the use of modern inputs.

Efficiency in Modern Input Use

It is useful to distinguish at this point between the two aspects of Pareto optimality in production, namely, production efficiency and allocative efficiency. A farmer may be considered to be technically efficient in the use of a modern technology if he applies fertilizers and pesticides correctly in accordance with the needs of his soil and his crops, organizes his labor force opportunely, performs tilling, plowing seeding and harvesting opperations correctly, etc. A farmer is efficient from an allocative standpoint if he uses the correct amount of his inputs in terms of bringing him the most profit.[3]

Both production and allocative efficiency are concepts traditionally defined within the context of a single production frontier for basic inputs such as land, labor, and capital. A premise of the present chapter is that two or more production technologies employing different intermediate inputs may coexist. This could be regarded, as Singh's description of the innovation process does, as a temporary adjustment phenomenon bound to occur during a period in which traditional firms become acquainted with a more profitable modern technology. But, the possibility that a potentially profitable technology may be unprofitable for a certain constellation of prices, also leaves room for the possibility that some constellation of prices will make the farmer indifferent between two, and even more, alternative technologies.

To this point, the analysis has concentrated on the individual farmer's profitability. It is important, however, to also consider

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[3]Discussions of technical and allocative efficiency may be found in Yotopoulos [1974], Timmer [1970] and Yotopoulos et al. [1970].

profitability from society's point of view. It is in this regard that the questioning by Tinnermeier [reported in Donald, 1976] and Adams [1971] of the rationale behind the use of credit as a means to promote modern technologies acquires significance.

As a starting point, the equity implications of Guatemala's credit program may be ignored. Then, for a modern technology to be a Pareto efficient option from society's point of view, condition (5) must hold for prices which truly reflect the opportunity cost of all outputs and inputs, including financial resources. The practice of Guatemala's credit program of providing credit to small farmers at subsidized rates of interest could lead to the use of technologies which are profitable from a farmer's point of view but excessive in the use of modern inputs, i.e., unprofitable to Guatemalan society from an efficiency standpoint. In essence, Guatemala's credit program could have been promoting both allocative and technical inefficiency.

An artificially low interest rate could have made it profitable for farmers to use amounts of capital intensive modern inputs which they could not have afforded otherwise. In terms of the two production technologies of the basic model, allocative inefficiency would have resulted if farmers shifted from using the production technology embodied in $f(\cdot)$ to that embodied in $g(\cdot, \cdot)$ in response to an artificially low rate of interest. The amounts of x_2 used by those employing the modern technologies could have also been excessive in comparison to the amounts they would have used if capital had been priced at its opportunity cost.

On the other hand, farmers unfamiliar with the use of modern inputs, x_2, could reasonably have expected a level of production from their combined use with x_1 which was lower than $g(x_1, x_2)$--say, equal to

$y = e^{\alpha} g(x_1, x_2)$ where $\alpha < 0$. Thus, an artificially low rate of interest could have brought about technical inefficiency by making it profitable for farmers to use modern technologies incorrectly.[4]

The achievement of a Pareto optimum, however, is a necessary but not a sufficient condition to the attainment of maximum social welfare [Winch, 1971, p. 94]. Acceptance of a preference ordering regarding the distribution of income and wealth among members of society is required in order to determine whether a given Pareto optimum coincides with the social welfare optimum.

The decision on the part of the Government of Guatemala to try to promote the use of modern inputs through subsidizing credit carried with it an implicit attempt to price the cost of capital at a socially optimal level. Such a social cost defined in this instance to include both efficiency and equity components of welfare. With the limited information available on the shape of Guatemala's social welfare function, the extent to which capital was optimally priced is beyond the scope of the present study.

The magnitude of governmental intervention in the capital market is likely to have been of more significance than the sum of individual farmer departures from price efficient allocative behavior. Moreover, as noted in Chapter I, the validity of available data for the analysis of credit induced differences in crop composition is doubtful. Yet, such

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[4] Since this involves the choice of wrong <u>basis</u> factor proportions embodied in the technological differences, allocative inefficiency is also implicit in this type of within-technology technical inefficiency.

differences are a central part of a farmer's allocative decisions.[5] Accordingly, in the present study the extent to which Guatemalan farmers were allocatively efficient is not subjected to empirical scrutiny.

Empirical tests in the present study concentrate on the technical efficiency in modern input use. Timmer [1973, p. 99] suggested that technical inefficiency is potentially more important quantitatively than allocative inefficiency. In determining the impact of credit upon small farmer efficiency in Guatemala, this could well have been the case.

If corn yields did not increase as a result of farmer participation in Guatemala's credit program, this could be because farmers used credit funds for purposes other than producing corn aided by the use of modern inputs. A test of this possibility is provided by H1 above. Alternatively, it could be because

H2: A technology making effective use of modern inputs did not exist;

or because

H3: The levels of productivity obtained by credit farmers using modern inputs were lower than their full potential.

It should be noted that H2 does not ask whether modern technologies available were profitable or not. It has already been illustrated how, with capital available at sufficiently low price, a modern potentially profitable technology of high working capital requirements can always be

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[5] A complete analysis of economic efficiency encompassing both allocative and technical efficiency would be best analyzed within the framework of the profit function. See Lau and Yotopoulos [1971] for details.

made effectively profitable.[6] If a technology that makes effective use of modern inputs is observable in the data, it is likely to have at least raised high profit expectations for farmers who were using them.

The issue raised by H2, however, is an important one within the Guatemalan context, for it has been forcefully argued that an appropriate technological package did not exist at the time the SCSG was instituted. An internal USAID Review of the Rural Development Program noted in 1972 that

> The lack of improved varieties and more particularly hybrid corn for the Altiplano does not appear to be a serious limitation to progress at this stage. The locally selective strains appear to be sufficiently responsive to both improved management and fertilizer, than the program can move ahead. [Patterson et al., 1972, Part III, p. 6]

Two years later, an appraisal of project performance pointed to such a lack of technology as the culprit behind the difficulty encountered by the SCSG in getting farmers to sign up for it and in getting them to use capital inputs (mainly fertilizer).

> The major restraint is that the program does not have a sufficiently reliable and realistic (from the farmer's viewpoint) package of income and yield increasing (or per unit of production cost reducing) technology for corn available to present to the farmer. [Hutchinson et al., 1974, p. 27]

H3 is presented as an alternative proposition. Original proponents of the SCSG had observed how some farmers used modern inputs that effectively increased corn yields and profits. It is one thing to say that such a technology did not really exist as H2 does. It is something

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[6] Another aspect which could affect a technology's profitability is the seriousness with which a farmer is made to regard his debt obligations. In the case of BANDESA's Trust Fund operations, about 14 percent of its loans were delinquent as of December 31, 1974 [BID-BIRF-AID, 1977, p. 58].

else to say, as implicit in the testing of H3, that this effective performance in modern input use could not be reproduced with ease.

Technical Assistance

Extension services in Guatemala, like most others in Latin America, originated as a product of development assistance efforts by the United States during the 1950s and early 1960s. The agencies created were patterned to follow the U.S. model if not the actual historical evolvement of the U.S. extension services. The Land Grant University system which evolved in the United States combined under one roof elements of agricultural research, education, and extension. The servicios instituted in Central America and in Andean countries emphasized, instead, the diffusion of technological innovation over the need to develop or adapt new technologies. It is not that the role of agricultural research and other services was not regarded as important. It is, rather, that the role of extension as a provider of information was seen as a dominant one given the stock of technical knowledge existing in the more advanced Western countries. The model that followed also regarded, as important, that the extension agent should be independent from credit granting, input supply and similar operations in order to gain farmers' confidence and acceptance.[7]

The extension services provided by DIGESA, under the SCSG, constituted a clear departure from the earlier models. The SCSG was designed to integrate technical assistance with credit. These two functions, in

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[7] For an excellent review of the genesis of extension services in Latin America and the role played by the United States in support of these services, see Rice [1971].

turn, were meant to be closely coordinated with other service activities under the umbrella of the Sector Público Agrícola.

Effect upon Modern Input Adoption

Despite the new approach adopted in the restructuring of the agricultural public sector, vestiges of the older system remained. Perhaps the weakest link in the process of innovation was between agricultural research and extension. Much research appears to have been undertaken in Guatemala in attempts to develop corn composites, lines and hydrids and to improve agronomic practices. But, if effective modern technologies existed, even in the sense of being successfully used by farmers in the field, it is uncertain whether DIGESA's promoters were sufficiently familiar with them to effectively promote their use. For example,

> In the Quetzaltenango region, the promoters are attempting to present a package of technology to farmers that utilizes the seed that the farmer presently uses, whereas, the impression that we had from the GOG technicians in the area (and from our own observations) is that the basic limiting factor to unit cost reduction is improved varieties adapted to the area. [Hutchinson et al., 1974, pp. 36-37]

It is then reasonable to expect that

> H4: DIGESA's promoters were ineffective in promoting modern input use.

Effect upon Improved Technical Efficiency

It is one thing to recommend that a farmer use modern inputs and to draw up his work plan and credit application accordingly. It is, of course, something else to be effective in teaching improved agricultural

practices to a farmer. Accordingly, the final hypothesis to be tested is

H5: DIGESA promoters were unsuccessful in improving the technical efficiency of the farmers they attended.

CHAPTER III
REVIEW OF EVIDENCE OF EFFECTS ON YIELDS

The immediate aim of the SCSG was to increase yields. It is thus important to review the extent to which increases in yield were obtained. In Tables 14 through 16, average yields for corn, beans and wheat are presented for a number of farms classified by region and credit group.[1] The estimated average corn yield for all corn producing BANDESA farms in Guatemala is 1840 kg/ha. The figure for non-BANDESA farms is 1720. Nevertheless, given the great variability in yields within both credit groups, the difference of 120 kg/ha does not constitute significant statistical evidence of a systematic relationship between credit groups and yields. Part of this variability can be appreciated by breaking down the data by regions and farm size. Only for less than 10 hectare

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[1] In order to analyze yield performance in basic grains there is no substitute for focusing upon yields at the crop level. The methodology developed in the GFPA [Daines, 1975a, Chapter 5] was not designed for the purpose of examining crop specific yields. The index used there to determine the impact on output attributable to yields is an index which aggregates over a number of crops. This means, for instance, that an increment in basic grain yields on the part of BANDESA farms accompanied by a reduction in the yields of their remaining crops could be registered by that methodology as if no change had occurred.

Also, there is a difference in the measures of yield utilized in the GFPA and that used in the construction of Tables 14-16. In the GFPA measure, each product carried a weight equivalent to the area used for its cultivation. The yield measure used in Tables 14-16 is a simple average of yields with every farm in each group carrying the same weight. These definitional differences are in keeping with the interests of each kind of analysis. The GFPA sought to determine aggregative impacts upon production. In this study we are concerned with changes in the economic behavior of farms.

Table 14. Corn: mean yield by size of farm and region

Region	< 10 hectares			> 10 hectares			All sizes		
	kg/ha	Number of observations	t^a	kg/ha	Number of observations	t^a	kg/ha	Number of observations	t^a
I									
BANDESA	1880	93	2.26	1350	12	-0.31	1810	105	2.00
Non-BANDESA	1580	119		1450	9		1570	128	
III									
BANDESA	1910	14	1.92	2200	14	0.75	2050	28	1.32
Non-BANDESA	1440	20		1560	15		1490	35	
IV									
BANDESA	2250	87	1.81	2060	33	-0.51	2190	120	1.01
Non-BANDESA	1900	76		2250	45		2040	121	
V									
BANDESA	1840	117	1.52	1530	69	0.03	1740	174	1.05
Non-BANDESA	1640	136		1520	38		1610	168	
VI									
BANDESA	1400	76	-1.32	2260	19	0.24	1590	95	-0.92
Non-BANDESA	1720	77		2120	32		1810	109	
All Regions									
BANDESA		NA		1900	147	-0.96	1840	534	1.32
Non-BANDESA				1920	139		1720	567	

[a] t-Statistic of difference of mean.

SOURCE: McDonald [1975].

Table 15. Beans: mean yield by size of farm and region

Region	< 10 hectares			> 10 hectares			All sizes		
	kg/ha	Number of observations	t[a]	kg/ha	Number of observations	t[a]	kg/ha	Number of observations	t[a]
I									
BANDESA	958	12	1.45	711	2		928	14	1.45
Non-BANDESA	691	24		114	1		666	25	
IV									
BANDESA	539	7	-1.78	613	3		565	10	-1.44
Non-BANDESA	903	12		324	1		856	13	
V									
BANDESA	1210	27	2.64	892	18	-1.09	1100	45	0.55
Non-BANDESA	718	24		972			787	49	
VI									
BANDESA	999	52	0.54	929	2	-0.11	984	65	0.44
Non-BANDESA	886	47		968	2		910	78	
All Regions									
BANDESA		NA		870	36	-0.51	963	134	0.92
Non-BANDESA				921	48		846	165	

[a]t-Statistic of difference of mean.

SOURCE: McDonald [1975].

Table 16. Wheat: mean yield by size of farm and region

Region	< 10 hectares			> 10 hectares			All sizes		
	kg/ha	Number of observations	t^a	kg/ha	Number of observations	t^a	kg/ha	Number of observations	t^a
I									
BANDESA	1490	93	-0.83	1210	12	-0.21	1460	105	-0.89
Non-BANDESA	1580	90		1250	9		1540	99	
VI									
BANDESA	1100	16	-2.69	1234	4		1120	20	-2.47
Non-BANDESA	1410	5			0		1410	5	
All regions									
BANDESA				1210	16	-0.65	1410	125	-2.92
Non-BANDESA				1250	9		1540	104	

[a] t-Statistic of difference of mean.

SOURCE: McDonald [1975].

farms in Region I can a statistically meaningful positive relationship be found between BANDESA status and yields. The case of beans is similar. Only for farms with less than 10 hectares in Region IV does there appear to be a favorable and significant yield response for BANDESA farmers. The situation appears very unfavorable for the credit group insofar as wheat is concerned. The differences between credit group estimated for each region and farm size classification are not estimated reliably because of the small number of observations. But, the direction of the estimated magnitudes is clear and negative in each case. The result is that, unlike the case for corn and for beans, the pooling of observations to estimate the all farms-all regions difference strongly suggests a systematic relationship by credit group. But, the relationship is opposite to that expected. The noted relationships indicate that even though in some instances some yield improvement can be detected on the part of BANDESA farmers, this improvement was neither widespread nor definitive.

There is an alternative fashion of classifying the data. The classification of farms by total area is an intuitively useful notion. Nevertheless, the functional unit in terms of credit and technical assistance is the plot of land used to produce the crop in question. When determining the amount of credit to be granted or the kind of technology that should be utilized in a given plot of land, the size of field dedicated to the crop in question is more relevant than the farm's overall size. Even though the amount of land in the farm, by definition, limits a plot's size, the correlation between the two measures is small (33 percent). It is pertinent to ask the extent to which yield conclusions are altered when making comparisons by plot size.

The equations summarized in Table 17 explore the possibility that both the level of corn output per hectare and its elasticity with respect to non-interplanted corn area sown on the field varies depending upon whether or not the farmer was a BANDESA credit recipient.

No perceptible difference by credit type can be detected for either the multiplicative or the elasticity term at a national level. These estimates, however, hide statistically meaningful differences at the regional level. While the difference in elasticity between BANDESA and non-BANDESA categories can be estimated only very imprecisely, the statistically significant positive difference in the multiplicative term suggests that, in general, BANDESA corn fields have a higher yield than similarly sized counterparts in Region I. Taking the fitted functions literally, the BANDESA yields are estimated to be higher in all corn fields which are 8.1 hectares or less. At that point, the fitted BANDESA and non-BANDESA curves intersect suggesting that yield superiority shifts in favor of non-BANDESA. Empirically, however, this segment of the fitted function is hardly relevant since no more than 3 percent of corn plots in Region I were more than 8 hectares. A similar pattern appears to hold for Region V except that the superiority of BANDESA plots is predicted to hold for any field size.

The higher yield in BANDESA corn fields does not hold in Regions IV and VI. The estimates of the parameters which suggest a difference by credit type are less efficiently estimated. Nevertheless, in both these regions the fitted functions suggest that non-BANDESA farms exhibit the higher yields throughout the sample range. Very little can be made of the differences estimated for Region III as neither difference parameter differs significantly from zero in a statistical sense. In fact, the

Table 17. Differences in elasticity of corn output per hectare of non-interplanted corn area cultivated, by credit type and region

Item	All regions	Separate regional equations				
		I	III	IV	V	VI
ε_N	0.02509 (0.85)	-0.08253 (1.38)	0.18656* (1.77)	0.16741 (2.40)	-0.2575*** (3.82)	0.09211 (1.28)
$(\varepsilon_B - \varepsilon_N)$	-0.01157 (0.28)	-0.08266 (0.81)	-0.06274 (0.37)	0.4836 (0.46)	0.25697*** (3.03)	-0.20596* (1.66)
$(k_B - k_N)$	0.04161 (0.82)	0.17316** (2.10)	0.31416 (1.05)	-0.26234* (1.66)	0.03085 (0.33)	-0.04642 (0.42)
k_N	4.00156	4.94905	4.66381	5.03229	4.99692	5.03510
F	0.61	3.76*	2.16	5.31***	6.62**	2.07*
R^2	0.00159	0.04148	0.09621	0.05652	0.05071	0.01479
No. of observations	1152	231	64	270	376	210

[a]The elasticity estimates are "gross" of other inputs [Bardhan, 1973]. They were obtained from the log linear regression of yield on non-interplanted corn area sown and corresponding parameter shifters for credit status:

$$\text{yield} = C_i \text{ Area}^{\varepsilon_i}$$

where $C_i = e^{k_i}$ and k_i is constant, for i = B(BANDESA), N(Non-BANDESA).

Values for the t-statistics are shown in parentheses below each coefficient.

*Significant at 10 percent level.

**Significant at 5 percent level.

***Significant at 1 percent level.

hypothesis that all of the parameters in the equation differ from zero can be rejected at a 90 percent level of significance.

The overall relationship between yield and plot size is generally consistent between credit groups. That is, the relationship is positive for both credit groups in Regions III and IV and negative in Region I. In Region V, the non-BANDESA group does not exhibit much of a relationship while the credit group does show a negative one. Only for Region IV are the patterns contradictory with BANDESA farms decreasing in yields with increases in farm size and the converse for non-BANDESA.

The aggregative analysis provided by the GFPA had suggested that increases in yields associated with participation in the SCSG had been minimal. Yield comparisons by credit group appear to be somewhat more favorable with regard to the intended effects of the SCSG as more disaggregated relationships are examined. But the basic conclusion of the GFPA cannot be challenged. Crop specific response to credit and technical assistance appears to have fallen short of the intended objective of increasing yields.[2]

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[2]The caveat made in Chapter I regarding the implications of the matching procedure used in drawing up the sample upon the statistical inferences to be derived, should be regarded here. To the extent that the resulting dependence between BANDESA and non-BANDESA observations is related to factors (such as, for example, land quality) which are positively correlated across credit category and which help determine yields, then the estimate of the variance of the difference between mean yields would be undervalued. In Tables 14 through 17, there can be greater assurance that the correct inference is being made in those cases which the analysis suggests not to reject the null hypothesis and to conclude, therefore, that there is no difference in mean yields, than in those cases in which difference in mean yields is apparent and the null hypothesis is rejected. Accordingly, the central conclusion of the present chapter, that there was no difference in mean yield response between BANDESA and non-BANDESA farmers, would not be challenged by tests which took into account the relative interdependence among sample observations.

Yield is a one dimensional measure of efficiency. The production attainable from a unit of land is, of course, a fundamental aspect of productivity. In general, however, there is a margin of possible substitution between other inputs and land. In order to trace why differences in yields failed to accompany farmer participation in the SCSG, it is important to determine the extent to which other inputs, particularly the modern inputs promoted by the SCSG, were in effect used by credit farmers. This is the subject of the following chapter.

CHAPTER IV
MODERN INPUT USE

The objective of the present chapter is to subject to empirical scrutiny the following two hypotheses developed in Chapter II:

H1: Credit was not a factor inducing the use of selected modern inputs.

H4: DIGESA's promoters were ineffective in inducing the use of selected modern inputs.

As an introduction to the information available on the subject in the SFBCS, some basic cross tabulations of the four modern inputs considered in the study are presented in the next section. These cross tabulations include improved seeds, fertilizers, insecticides and machinery by participation in the BANDESA credit program, regional location of the farmer and farm size. To the extent that other variables which exert an influence upon modern input use are correlated with participation in the SCSG, it is important to try to distinguish between their effects and those associated with such participation. For this purpose and in an attempt to distinguish between the separate effects of credit and technical assistance, a multivariate logit model of modern input use is subsequently formalized and used to test H1 and H4.

It is important to be clear at the outset as to what can and cannot be established from evidence available on a cross section of farms. It is possible to determine whether a farmer used or did not use a given input in 1973. It is also possible to identify analytically a number of

characteristics which could help determine such utilizations. It is on the basis of differences in the rates of utilization between groups of farmers with different characteristics that it can be established, with varying degrees of statistical reliability, whether a given characteristic exerts an influence upon the utilization of these inputs. What is less certain is the extent to which these differences constitute differences in adoption rates in the full meaning of the word. A farmer could be observed using fertilizers solely for the purpose of pleasing the credit promoter or extension agent. Only time series data could establish the extent to which SCSG participants discard the use of an input once their participation in the program has ended. Nevertheless, as long as the utilization of an input is profitable to a farmer, regardless of the motivations behind his original use, the suggestion that he will abandon the use of this input presupposes a very peculiar behavior on his part. In Chapter V of this dissertation, the extent to which the utilization of modern inputs was productive is explored.

Modern Input Use by SCSG Participation Status, Region and Farm Size

In Chapter II it was shown how improvements in agricultural productivity and profitability may be intimately related to the qualitative character of the inputs utilized. Chapter 8 of the GFPA showed how expenditures in modern inputs are positively associated with participation in the BANDESA credit program. It is then likely that these expenditure differences reflect in part a larger rate of modern input utilization among BANDESA farmers. This possibility is examined here.

In Tables 18 and 19, the frequency of use on corn production fields of four modern inputs--fertilizer, insecticide, machinery and improved seeds--and a traditional one--animal power--by categories of BANDESA participation status and region is provided. It should be noted that these tabulations do not represent ownership of these inputs. A special effort was made by the SFBCS to distinguish between flows which enter into field-specific production processes and the stock value of various capital goods. The tabulations presented give estimates of the number of non-interplanted corn fields on which an input was used whether that input was rented, borrowed or owned.[1]

Without regard to credit category, the frequency of use of all inputs is rather low (Table 18). Fertilizer was used in about 60 percent of the corn fields while the use of animal power, machinery, hybrid corn seeds and insecticides was close to 32 percent in each case.

The differences by credit type are, nevertheless, remarkable. Whereas some forms of chemical fertilizer were used in 75 percent of the BANDESA corn fields, the comparative rate of use was 44 percent for non-BANDESA corn fields, a use ratio of 1.70. This ratio of BANDESA use to that of non-BANDESA equals 1.59, 1.42 and 1.38 for insecticides, improved seeds and machinery, respectively, indicating the higher rate

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[1]Unlike the other modern inputs considered, the services from a given machinery equipment may be used over a number of years. This implies that an investment in machinery is only partially related to its productivity in a given year. It could be argued that any systematic observation of participation in BANDESA and the use of machinery during 1973 should be deemed coincidental, or at any rate unrelated to inducement of machinery use. The fact is, however, that out of the 340 farms in the sample which used machinery in the production of non-interplanted corn, only 29 used their <u>own</u> machinery, the remaining 311 used rented machinery. This places much of the machinery services on the same footing as the capital flows from the other modern inputs under consideration.

Table 18. Use of selected inputs in corn fields, by credit type[a]

Credit type	Fertilizer	Insecticide	Improved seeds	Animal power	Machinery
Non-BANDESA	44.3[b] (1944)[c]	24.6 (1079)	26.9 (1182)	35.6 (1562)	26.6 (1169)
BANDESA	75.1 (3058)	39.3 (1603)	38.2 (1557)	31.9 (1298)	36.8 (1498)
No credit distinction	59.7 (5002)	31.7 (2681)	32.4 (2738)	33.8 (2860)	31.5 (2667)

[a]In all, it is estimated that there were 4387 non-BANDESA fields and 4073 BANDESA fields for a total of 8460 corn fields.

[b]Percent using input.

[c]Estimated number of fields in which the input was used.

Table 19. Use of selected inputs in corn fields, by region

Region	Fertilizer	Insecticides	Improved seeds	Animal power	Machinery
I. Central Highlands	75.5[a] (1802)[b]	10.8 (259)	8.9 (212)	16.7 (398)	9.4 (223)
II. South Coast (West)	32.3 (208)	51.6 (332)	12.9 (83)	19.4 (125)	46.8 (301)
III. South Coast (East)	40.1 (737)	67.7 (1244)	49.9 (918)	29.6 (544)	65.0 (1195)
IV. Northeast	41.5 (632)	26.1 (397)	32.8 (499)	30.4 (462)	34.0 (517)
V. Southeast Highlands	78.4 (1623)	21.7 (449)	49.6 (1027)	64.3 (1331)	20.8 (430)

[a]Percent using input.

[b]Estimated number of fields in which the input was used.

of use by credit farmers. Only for a non-modern input, animal power, does the use ratio, 0.89, suggest some similarity of input use.

The regional variations in percentage of use are also large (Table 19). The frequencies of fertilizer use were highest in the Central Highlands (75 percent) and Southeast Highlands (78 percent) where the soils of poorest quality may be found. These rates contrast sharply with those observed in the South Coast, both West (32 percent) and East (40 percent) and in the Northeast (41 percent).

The pattern of use of insecticides is almost the reverse of that for fertilizers. Insecticides are most widespread in the South Coast fields, both West (52 percent) and East (68 percent) where humidity provides a fertile environment for pests.

The pattern of use of improved or hybrid corn seeds differs, in turn, with the use of fertilizers and insecticides. Thus, as is the case for insecticides, the lowest rate of utilization of improved seeds is found in the Central Highlands (9 percent). But, as is the case for fertilizer, one of the highest rates of improved seed use (50 percent) is found in the Southeast Highlands.

Unlike the modern inputs, there appeared to be no remarkable differences in the use of animal power by credit type at the national level. The same cannot be said of regional differences in the frequency of use of animal power. Much use of animal power was concentrated in the Southeast Highlands, where it was used in 64 percent of the corn fields. By way of contrast, the next region where use of animal power was most widespread was the Northeast where this input was used in only about 30 percent of the fields.

Insofar as the regional pattern of machinery use is concerned, it closely resembles that of insecticides. That is, machinery is most widespread in the South Coast where commercial agriculture is dominant. As in the case with insecticides, the machinery use rates are lowest in the Central Highlands (9 percent), whereas intermediately low rates are found in the Northeast (34 percent) and in the Southeast Highlands.

Given that input use rates differ across regional boundaries, it is important to examine the extent to which the higher rates of use of modern inputs by BANDESA farmers holds within regions. In Table 20 the rate of use of each of the five inputs--fertilizer, insecticides, improved seeds, animal power and machinery--by credit type for each of the five regions is presented. For the four modern inputs, the within-region use rate for non-BANDESA was higher than that for BANDESA fields in only one category, namely, insecticide use in the Central Highlands, a case for which both ratios are low (15.2 percent and 5.5 percent, respectively). In the remaining 19 modern input comparisons, the utilization rate for BANDESA farms was higher. Insofar as the more traditional input, animal power, is concerned, the opposite is true. Only in the East South Coast (36 percent) is the BANDESA utilization rate of animal power higher than that of non-BANDESA corn fields (32 percent).

Finally, to check for the possibility that the higher adoption rates of modern inputs in corn fields was concentrated in a limited number of farm size categories (e.g., small farms), Tables 21 through 25 give the region and farm size specific rates of the various inputs. Since, for many of the categories defined in these tables, there are no observations available, the number of comparisons which can be made

Table 20. Use of selected inputs in corn fields by credit status and by region

Region and credit status	Fertilizer	Insecticide	Improved seeds	Animal power	Machinery
I. Central Highlands					
Non-BANDESA	64.1[a] (842)[b]	15.2 (200)	8.5 (112)	17.4 (229)	7.8 (103)
BANDESA	89.6 (961)	5.5 (58)	9.3 (99)	15.8 (168)	11.2 (120)
III. South Coast (West)					
Non-BANDESA	2.9 (10)	35.3 (125)	11.8 (42)	29.4 (104)	35.3 (125)
BANDESA	67.9 (197)	71.4 (208)	14.3 (42)	7.1 (21)	60.7 (177)
IV. South Coast (East)					
Non-BANDESA	21.2 (184)	52.8 (460)	32.2 (280)	28.0 (244)	54.3 (473)
BANDESA	57.2 (533)	81.1 (785)	65.9 (638)	31.0 (300)	74.7 (722)

Table 20. Continued.

Region and credit status	Fertilizer	Insecticide	Improved seeds	Animal power	Machinery
V. Northeast					
Non-BANDESA	25.7 (198)	19.3 (149)	29.5 (228)	31.4 (242)	32.1 (248)
BANDESA	57.9 (433)	33.1 (248)	36.1 (270)	29.4 (220)	35.9 (269)
VI. Southeast Highlands					
Non-BANDESA	65.9 (709)	13.5 (145)	48.3 (520)	69.0 (743)	20.4 (220)
BANDESA	92.0 (914)	30.5 (303)	51.0 (507)	59.1 (588)	21.1 (210)

[a]Percent using input.

[b]Estimated number of fields in which this input was used.

Table 21. Use of fertilizer in corn fields by credit type, region and farm size

Region and credit status	Farm size in hectares							
	0-1	1-3	3-5	5-10	10-20	20-50	50-100	100+
I. Central Highlands								
Non-BANDESA	49.0[a]	71.7	64.4	67.7	83.6	66.0	--	--
	(175)[b]	(301)	(136)	(147)	(53)	(31)	--	--
BANDESA	72.5	92.0	86.9	95.8	79.4	100.0	--	--
	(32)	(487)	(193)	(140)	(85)	(24)	--	--
III. South Coast (West)								
Non-BANDESA	--	0	33.3	0	0	--	0	--
	--	0	(10)	0	0	--	0	--
BANDESA	--	50.0	71.4	66.7	80.0	--	100.0	--
	--	(21)	(52)	(21)	(83)	--	(21)	--
IV. South Coast (East)								
Non-BANDESA	--	22.8	25.4	30.7	15.0	34.9	--	--
	--	(50)	(28)	(44)	(47)	(16)	--	--
BANDESA	--	73.2	72.3	54.3	53.8	33.0	--	--
	--	(91)	(117)	(211)	(110)	(24)		

Table 21. Continued.

Region and credit status	Farm size in hectares							
	0-1	1-3	3-5	5-10	10-20	20-50	50-100	100+
V. Northeast								
Non-BANDESA	28.5 (18)	27.6 (87)	22.4 (36)	20.8 (20)	42.3 (29)	13.1 (8)	0 0	-- --
BANDESA	66.2 (8)	70.2 (161)	61.1 (63)	43.4 (73)	46.5 (69)	71.2 (40)	60.6 (13)	64.3 (7)
VI. Southeast Highlands								
Non-BANDESA	23.8 (8)	53.2 (190)	55.9 (181)	86.9 (104)	89.9 (77)	89.4 (73)	-- --	-- --
BANDESA	100.0 (13)	100.0 (258)	89.4 (274)	84.1 (166)	83.8 (81)	100.0 (118)	-- --	-- --

[a]Percent using input.

[b]Estimated number of fields on which this input was used.

Table 22. Use of insecticides on corn fields by credit type, region and farm size

Region and credit status	Farm size in hectares							
	0-1	1-3	3-5	5-10	10-20	20-50	50-100	100+
I. Central Highlands								
Non-BANDESA	4.5[a]	17.9	13.6	22.7	16.4	44.0	--	--
	(16)[b]	(75)	(29)	(49)	(10)	(21)		
BANDESA	13.8	5.3	4.7	9.5	0	0	--	--
	(6)	(28)	(10)	(14)	0	0	--	--
III. South Coast (West)								
Non-BANDESA	33.3	0	0	55.6	33.3	100.0	0	--
	(10)	0	0	(52)	(42)	(21)	0	--
BANDESA	--	75.0	71.4	100.0	70.0	0	100.0	--
	--	(31)	(52)	(31)	(73)	0	(21)	--
IV. South Coast (East)								
Non-BANDESA	--	42.7	23.8	70.7	64.7	82.5	--	--
	--	(93)	(26)	(102)	(201)	(37)	--	--
BANDESA	--	62.2	64.1	88.3	92.1	78.0	--	--
	--	(77)	(104)	(342)	(189)	(56)	--	--

Table 22. Continued.

Region and credit status	Farm size in hectares							
	0-1	1-3	3-5	5-10	10-20	20-50	50-100	100+
V. Northeast								
Non-BANDESA	7.2 (5)	22.0 (69)	20.0 (32)	15.8 (15)	30.9 (21)	11.0 (7)	0 0	-- --
BANDESA	0 0	46.1 (105)	31.7 (33)	31.8 (54)	19.2 (28)	26.9 (15)	33.2 (7)	52.4 (6)
VI. Southeast Highlands								
Non-BANDESA	0 0	4.4 (16)	17.4 (56)	6.6 (8)	28.5 (24)	20.3 (17)	31.7 (24)	-- --
BANDESA	33.4 (4)	31.5 (81)	34.4 (105)	19.3 (38)	46.8 (45)	20.9 (25)	-- --	-- --

[a]Percent using input.

[b]Estimated number of fields on which this input was used.

Table 23. Use of improved seeds in corn fields by credit type, region and farm size

Region and credit status	Farm size in hectares							
	0-1	1-3	3-5	5-10	10-20	20-50	50-100	100+
I. Central Highlands								
Non-BANDESA	17.9[a] (64)[b]	11.4 (48)	0 0	0 0	0 0	-- --	-- --	-- --
BANDESA	0 0	6.9 (37)	4.7 (10)	29.1 (42)	9.6 (10)	-- --	-- --	-- --
III. South Coast (West)								
Non-BANDESA	-- --	0 0	-- --	11.1 (10)	8.3 (10)	50.0 (10)	-- --	-- --
BANDESA	-- --	25.0 (10)	-- --	0 0	10.0 (10)	0 0	-- --	-- --
IV. South Coast (East)								
Non-BANDESA	11.8 (5)	28.3 (62)	37.1 (41)	45.6 (66)	27.5 (85)	46.8 (21)	-- --	-- --
BANDESA	-- --	61.4 (76)	65.2 (106)	60.9 (236)	68.0 (139)	89.0 (64)	-- --	-- --

Table 23. Continued.

Region and credit status	Farm size in hectares							
	0-1	1-3	3-5	5-10	10-20	20-50	50-100	100+
V. Northeast								
Non-BANDESA	30.7 (19)	22.9 (72)	47.9 (76)	26.0 (26)	26.1 (18)	27.9 (17)	0 0	-- --
BANDESA	0 0	34.0 (78)	35.6 (37)	38.4 (65)	38.9 (57)	44.8 (25)	33.2 (7)	11.9 (1)
VI. Southeast Highlands								
Non-BANDESA	0 0	44.1 (157)	48.6 (157)	70.1 (84)	37.7 (32)	64.5 (52)	47.6 (37)	-- --
BANDESA	33.3 (4)	65.8 (170)	42.1 (129)	51.3 (101)	63.1 (61)	31.2 (37)	-- --	-- --

[a]Percent using input.

[b]Estimated number of fields on which this input was used.

Table 24. Use of animal power in corn fields by credit type, region and farm size

Region and credit status	Farm size in hectares							
	0-1	1-3	3-5	5-10	10-20	20-50	50-100	100+
I. Central Highlands								
Non-BANDESA	7.5[a]	21.4	21.1	20.7	0	22.0	--	--
	(27)[b]	(90)	(57)	(45)	0	(10)	--	--
BANDESA	55.1	9.2	24.4	2.4	35.5	0	--	--
	(24)	(49)	(54)	(3)	(38)	0	--	--
III. South Coast (West)								
Non-BANDESA	--	75.0	66.7	11.1	25.0	50.0	--	--
	--	(31)	(21)	(10)	(31)	(10)	--	--
BANDESA	--	25.0	0	0	10.0	0	--	--
	--	(10)	0	0	(10)	0	--	--
IV. South Coast (East)								
Non-BANDESA	--	13.3	29.0	45.7	29.8	54.0	--	--
	--	(29)	(32)	(66)	(93)	(24)	--	--
BANDESA	--	16.7	34.6	26.3	43.4	22.5	--	--
	--	(21)	(56)	(102)	(89)	(16)	--	--

Table 24. Continued.

Region and credit status	Farm size in hectares							
	0-1	1-3	3-5	5-10	10-20	20-50	50-100	100+
V. Northeast								
Non-BANDESA	48.5	36.9	12.0	33.4	29.1	39.1	0	--
	(31)	(116)	(19)	(33)	(20)	(24)	0	--
BANDESA	27.9	40.3	39.1	17.9	17.5	42.1	21.2	--
	(3)	(92)	(40)	(30)	(26)	(24)	(5)	--
VI. Southeast Highlands								
Non-BANDESA	26.2	65.1	75.4	60.6	57.2	--	--	--
	(9)	(232)	(244)	(73)	(49)	--	--	--
BANDESA	33.3	53.2	68.5	45.5	75.7	--	--	--
	(4)	(138)	(210)	(90)	(73)	--	--	--

[a]Percent using input.

[b]Estimated number of fields on which this input was used.

Table 25. Use of machinery in corn fields by credit type, region and farm size

Region and credit status	Farm size in hectares							
	0-1	1-3	3-5	5-10	10-20	20-50	50-100	100+
I. Central Highlands								
Non-BANDESA	4.5[a]	6.3	0	23.2	0	22.0	--	--
	(16)[b]	(26)	0	(50)	0	(10)	--	--
BANDESA	0	11.9	3.1	7.1	14.9	100.0	--	--
	0	(63)	(7)	(10)	(16)	(24)	--	--
III. South Coast (West)								
Non-BANDESA	--	0	0	55.6	41.7	--	--	--
	--	0	0	(52)	(52)	--	--	--
BANDESA	--	75.0	71.4	0	70.0	--	--	--
	--	(31)	(52)	0	(73)	--	--	--
IV. South Coast (East)								
Non-BANDESA	--	31.6	15.0	58.3	89.8	54.0	--	--
	--	(69)	(17)	(84)	(279)	(24)	--	--
BANDESA	--	42.1	42.8	83.4	100.0	78.0	--	--
	--	(52)	(70)	(324)	(205)	(56)	--	--

Table 25. Continued.

Region and credit status	Farm size in hectares							
	0-1	1-3	3-5	5-10	10-20	20-50	50-100	100+
V. Northeast								
Non-BANDESA	21.6	37.4	40.0	20.4	24.2	26.2	0	--
	(14)	(118)	(64)	(20)	(17)	(16)	0	--
BANDESA	38.3	43.3	59.4	32.8	11.5	48.5	21.2	--
	(5)	(99)	(61)	(55)	(17)	(27)	(5)	--
VI. Southeast Highlands								
Non-BANDESA	--	8.8	26.0	19.7	14.3	44.2	--	--
	--	(31)	(84)	(24)	(12)	(36)	--	--
BANDESA	--	10.9	19.8	18.2	41.6	38.1	--	--
	--	(28)	(61)	(36)	(40)	(45)	--	--

[a]Percent using input.

[b]Estimated number of fields on which this input was used.

between the percent of BANDESA and of non-BANDESA fields in which a given input was used is limited: 24 for fertilizers, 21 for insecticides, 17 for improved seeds, 22 for animal power and 20 for machinery. Nevertheless, these comparisons strongly support the notion that modern input use rates are higher for BANDESA farms independent of region or farm size classification. The proportion of the comparisons which can be made in which BANDESA fields show a higher rate of input use than non-BANDESA fields is equal to 83, 76, 70 and 75 percent in the case of fertilizers, insecticides, improved seeds and machinery, respectively, whereas it is only equal to 45 percent in the case of animal power.

Multivariate Logit Model of Modern Input Use

It is clear from the previous comparisons that participation in the BANDESA credit program is associated with a greater propensity to use modern inputs. In these comparisons, adjustments were made to isolate the credit impact effects from the influence which differences in region and farm size might have also exerted. But, beyond these adjustments, little was determined concerning the separate role of credit and technical assistance. Furthermore, no attempt was made to explore the possible role which other variables might have had.

A multivariate logit model is used in the present section in an attempt to differentiate the impact of the various determinants of modern input use. First, the nature and basic assumptions of the model are discussed. Second, the characteristic features of the measures of the variables of interest available through the SFBCS are discussed. Third, the results of applying the model are presented and analyzed.

The section concludes with some examples which help to illustrate the implications of the results obtained.

Model

Consider the probability P that a farmer uses fertilizer in the production of corn. The point of departure for single equation models of categorical data is a specification such as

$$P = F(\beta'X)$$

where $F(\cdot)$ is a cumulative distribution function (c.d.f.), X is a vector of characteristics of the farmer and β is a parameter vector. Such a specification ensures that P lies within an admissible interval $0 \leq P \leq 1$. The choice of c.d.f. is to some extent arbitrary [Maddala and Nelson, 1974]. By setting

$$P = \frac{1}{1 - e^{-\beta'X}}$$

the logarithm of the odds that a farmer will use fertilizer may be expressed as a simple linear function of exogenous variables,

$$\log \left[\frac{P}{1 - P}\right] = \beta'X .$$

A natural extension to the multivariate case is obtained by focusing upon the odds that an event will happen relative to its converse. Consider the four way dichotomous case and let

$$P(Y_1 = i; Y_2 = j; Y_3 = k; Y_4 = \ell) \equiv P_{ijk\ell}$$

$$\text{for } i, j, k, \ell = 0, 1.$$

Denote conditional probabilities by dots such as

$$P(Y_1 = i \mid Y_2, Y_3, Y_4) \equiv P_{i\ldots}$$

The logarithm of the conditional odds that each of the four events will occur may be written as

$$\begin{aligned}
\ln\left[\frac{P_{1\ldots}}{P_{0\ldots}}\right] &= \beta_1'X + \alpha_{12}Y_2 + \alpha_{13}Y_3 + \alpha_{14}Y_4 \\
\ln\left[\frac{P_{.1..}}{P_{.0..}}\right] &= \beta_2'X + \alpha_{21}Y_1 + \alpha_{23}Y_3 + \alpha_{24}Y_4 \\
\ln\left[\frac{P_{..1.}}{P_{..0.}}\right] &= \beta_3'X + \alpha_{31}Y_1 + \alpha_{32}Y_2 + \alpha_{34}Y_4 \\
\ln\left[\frac{P_{...1}}{P_{...0}}\right] &= \beta_4'X + \alpha_{41}Y_1 + \alpha_{42}Y_2 + \alpha_{43}Y_3
\end{aligned} \qquad (11)$$

It can be shown that the equations in (1) imply

$$\begin{aligned}
\alpha_{12} &= \alpha_{21} & \qquad \alpha_{23} &= \alpha_{32} \\
\alpha_{13} &= \alpha_{31} & \qquad \alpha_{24} &= \alpha_{42} \\
\alpha_{14} &= \alpha_{41} & \qquad \alpha_{34} &= \alpha_{43}
\end{aligned}$$

(For the two dependent variable cases see, e.g., Schmidt and Strauss [1975].) These symmetry conditions allow each of the individual probabilities to be written as logistic:

$$
\begin{aligned}
P_{0000} &= 1/D \\
P_{1000} &= e^{\beta_1' X}/D \\
P_{0100} &= e^{\beta_2' X}/D \\
P_{0010} &= e^{\beta_3' X}/D \\
P_{0001} &= e^{\beta_4' X}/D \\
P_{1100} &= e^{(\beta_1 + \beta_2)'X + \alpha_{12}}/D \\
P_{1010} &= e^{(\beta_1 + \beta_3)'X + \alpha_{13}}/D \\
P_{1001} &= e^{(\beta_1 + \beta_4)'X + \alpha_{14}}/D \\
P_{0110} &= e^{(\beta_2 + \beta_3)'X + \alpha_{23}}/D \\
P_{0101} &= e^{(\beta_2 + \beta_4)'X + \alpha_{24}}/D \\
P_{0011} &= e^{(\beta_3 + \beta_4)'X + \alpha_{34}}/D \\
P_{1110} &= e^{(\beta_1 + \beta_2 + \beta_3)'X + \alpha_{12} + \alpha_{13} + \alpha_{23}}/D \\
P_{1101} &= e^{(\beta_1 + \beta_2 + \beta_4)'X + \alpha_{12} + \alpha_{14} + \alpha_{24}}/D \\
P_{1011} &= e^{(\beta_1 + \beta_3 + \beta_4)'X + \alpha_{13} + \alpha_{14} + \alpha_{34}}/D \\
P_{0111} &= e^{(\beta_2 + \beta_3 + \beta_4)'X + \alpha_{13} + \alpha_{24} + \alpha_{34}}/D
\end{aligned}
\tag{12}
$$

$$P_{1111} = e^{(\beta_1 + \beta_2 + \beta_3 + \beta_4)'X + \alpha_{12} + \alpha_{13} + \alpha_{14} + \alpha_{23} + \alpha_{24} + \alpha_{34}}/D$$

where

$$D = 1 + \sum_{i=1}^{4} e^{\beta_i' X} + \sum_{i=1}^{3} \sum_{\substack{i<j \\ j=2}}^{4} e^{(\beta_i + \beta_j)'X + \alpha_{ij}}$$

$$+ \sum_{i=1}^{2} \sum_{\substack{j>i \\ j=2}}^{3} \sum_{\substack{k>j \\ k=3}}^{4} e^{(\beta_i + \beta_j + \beta_k)'X + \alpha_{ij} + \alpha_{ik} + \alpha_{jk}}$$

$$+ e^{(\beta_1 + \beta_2 + \beta_3 + \beta_4)'X + \alpha_{12} + \alpha_{13} + \alpha_{14} + \alpha_{23} + \alpha_{24} + \alpha_{34}}$$

or compactly as

$$\begin{aligned} P_{ijk\ell} = \{\exp[& (\beta_1 Y_1 + \beta_2 Y_2 + \beta_3 Y_3 + \beta_4 Y_4)'X + \alpha_{12} Y_1 Y_2 \\ & + \alpha_{13} Y_1 Y_3 + \alpha_{14} Y_1 Y_4 + \alpha_{23} Y_2 Y_3 + \alpha_{24} Y_2 Y_4 \\ & + \alpha_{34} Y_3 Y_4]\} \div D \end{aligned} \tag{13}$$

where

$$i = Y_1 = 0, 1$$

$$j = Y_2 = 0, 1$$

$$k = Y_3 = 0, 1$$

$$\ell = Y_4 = 0, 1$$

and D is the same as above.

Suppose there are T random sample observations of exogenous $x^{(t)}$ and endogenous $y^{(t)'} = (y_1, y_2, y_3, y_4)_t$ $t = 1, \ldots, T$ vectors of the four way dichotomy. Then, the maximum likelihood estimator of the unknown parameters (the β and α above) is obtained by maximizing the likelihood function.

$$L = \prod_{t=1}^{T} P_{ijk\ell}^{(t)} \tag{14}$$

In (14) $P_{ijk\ell}^{(t)}$ is obtained by replacing the values of X and Y in (13) with the sample values $x^{(t)}$ and $y^{(t)}$ of the t^{th} observation. As no simple analytical form for the maximized value of (14) can be obtained, numerical approximation needs to be used. The estimates so obtained are full information maximum likelihood under the assumptions implicit in model (11). Consequently, they possess the desirable large sample properties of consistency and asymptotic efficiency.

The model discussed is taken from Nerlove and Press [1973] and Schmidt and Strauss [1975]. It is not the most general one that can be envisioned. Rather than start from the logarithm of the odds as in (11) expressed as a linear function of exogenous and endogenous variables, the four-way dichotomy could be treated as a multinomial model with 16 categories. Maddala and Nelson [1974] have shown these two models to be equivalent only after a number of restrictions have been imposed upon the multinomial model. In particular, dependent variable interactions of order higher than two are assumed to be zero in (11). Also, in its most general form, the multinomial model cannot be estimated as it involves too many parameters.

Variables[2]

An empirically useful distinction made in the statistical analysis of this study is between BANDESA farmers who received credit assistance

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[2]The characteristic features of the variables employed in the empirical analysis are discussed in this section. A precise statement defining the variables used in reference to the SFBCS is given in the Appendix.

in the cultivation of corn and those who received credit to be used in the production of other crops. This distinction presupposes that credit it not a liquid input with its impact felt through all of the farm's activities. While this condition is contrary to what economic theory might suggest, it is in keeping with the institutional constraints which the SCSG imposed upon BANDESA farmers. Both credit agents and extensionists were responsible for monitoring compliance with the work plan and had the power to stop disbursement whenever credit was used for other than the purpose intended. The extent to which they were effective is an empirical issue of some interest. More importantly, if the amount of corn credit had an impact upon modern input use over and above the impact associated with the simple fact that credit was received, i.e., with BANDESA status, it is important that this effect be detected. Both of these measures are used in the empirical testing of H1 (DBANDESA and CORNCREDIT).

It is widely believed by international personnel who worked in Guatemala in 1973 that both BANDESA and DIGESA worked in such coordination in the implementation of the SCSG that it is impossible to distinguish their separate roles. The operational rule was the tying of credit to technical assistance. It has been contended that the role of the extension agent and that of the credit promoter often became one and the same, particularly in the direction of both becoming credit promoters to the detriment of the technical assistance function.

The independent role of each kind of assistance cannot be distinguished in all its facets. In effect, the cross tabulation of corn fields--both estimated and sample observations--by whether they were worked by farmers who received BANDESA credit, whether such credit was

provided for corn production and whether the farmer received some technical assistance on corn production techniques (Table 26) suggests that in practice BANDESA and DIGESA did play the intended complementary roles. Of those BANDESA corn plots with corn specific credit, it is estimated that 80 percent had one contact with technical assistance personnel. Only in 21 percent of the remaining corn plots--non-BANDESA or BANDESA with credit in some other crop--was some technical assistance provided. Given the minimal variation in categorical variability and the type of information provided by the data, it is very difficult to determine the extent to which BANDESA agents and DIGESA promoters interchanged roles.

Nevertheless, the data were collected such that it was the farmer himself who classified a contact as one of technical assistance in the various crops. The measure used here in the testing of H4 is the number of contacts of technical assistance on corn received by the farmer (DNMTECHAS). Such contacts include classes, demonstrations and personal visits.[3] It should be noted that the potential source of information provided by this measure is a rich one. Despite the categorical correlation between credit and technical assistance, the correlation coefficient between the amount of corn specific credit and the number of visits of technical assistance on corn is only .07.

To provide for an unbiased test of H1 and H4, other variables which might exert an influence upon modern input use have been included in the statistical analysis. Given the noted differences in natural resource endowment, capital availability, cultural heritage, and modern

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[3]For further details characterizing the nature of these contacts, see Ricardo [1975, p. 16].

Table 26. Cross tabulation of corn fields by BANDESA status, corn specific BANDESA credit and technical assistance on corn

Class	No technical assistance on corn	At least one contact of technical assistance on corn
BANDESA corn credit > 0	474[a] (64)[b]	1897 (284)
BANDESA credit on other field	1133 (146)	570 (65)
Non-BANDESA	3713 (471)	674 (103)

[a]Estimated number of fields.

[b]Unweighted number of sample observations.

input use across regional boundaries in Guatemala, a regional classification which distinguishes between the Central Highlands (Region I), the South Coast (Regions III and IV), the Northeast (Region V) and the Southeast Highlands (Region VI) is postulated to exert an influence upon modern input use (DREG34, DREG5, DREG6). No distinction is made between the two coastal regions because of the limited number of observations available. This procedure should not impart considerable bias in the resulting analysis. As has been noted in the categorical tabulations, only in the case of improved seeds is there reason to suspect that the pattern of input use between these two regions might differ.

A larger number of years of schooling (EDCN) would be expected to enhance a farmer's understanding of modern agricultural practices and, hence, to induce the use of modern inputs. Age (AGE), on the other hand, would be positively related with modern input use to the extent that it reflects farming experience or, alternatively, could work against modern input use to the extent that it is associated with a traditional reluctance to change old proven, even if less profitable, ways.

The farther away a farmer is from his market, the higher his total cost is likely to be of using modern inputs. Also, distance from markets will tend to adversely affect the price which a farmer will receive for his product. Both of these factors suggest that the farmer's distance from the center in which he makes the majority of his purchases and sales (DISTANCE) affects the probability of modern input use [Robertson et al., 1975, p. 25; i.e., page 2 of SFBCS questionnaire].

Large farms are often regarded as specially apt for adopting modern technologies. The correlation between farm size (ARABLE) and a capacity

to generate working capital presumably facilitates their purchase of modern inputs.

A similar argument is applicable to the relative dependence upon basic grains (CORNFLA). In the case of Guatemala, it could be stipulated that the larger the amount of land used to produce corn, the smaller the farmer's capacity to generate working capital. A large dependence on corn could also reflect an established tradition of subsistence agriculture and a low level of commercialization in the region where the farmer is found. These factors would tend to adversely affect modern input use.

Finally, it is reasonable to expect certain carry-over effects insofar as the adoption of modern inputs is concerned. Pest control, for example, may be essential for other inputs to be effective. Use of any other modern input will not have an effect on yields if pests destroy the crops. Similarly, fertilizer is most productive when used in combination with improved seeds. Similar arguments could be regarded as applicable with respect to interactions between the various modern inputs under specific circumstances. To determine their empirical validity, first order interaction terms are included in the statistical analysis (DURFERT, DMACH, DINSECT, DIMPSEED).

Results

In Table 27, the coefficients estimated for each of four indices which help determine the use of the four modern inputs are given. The discussion of these results is centered around the variables which make up these indices.

Table 27. Multivariate logit analysis of modern input use[a]

Variables		Coefficients			
Code	Description	Fertilizer (DURFERT)	Machinery (DMACH)	Insecticides (OINSECT)	Improved seeds (OIMPSEED)
	Explanatory variables				
DREG34	1 if in Region III or IV; 0 if not	-1.65*** (11.33)	1.18*** (7.63)	1.37*** (9.08)	0.89*** (5.27)
DREG5	1 if in Region V; 0 if not	-1.14*** (10.01)	0.81*** (5.50)	0.37*** (2.78)	0.93*** (5.91)
DREG6	1 if in Region VI; 0 if not	-0.25** (1.99)	0.26 (1.57)	0.19 (1.35)	1.23*** (7.88)
DBANDESA	1 if BANDESA; 0 if not	0.54*** (6.00)	-0.18* (1.90)	0.058 (0.61)	-0.00069 (0.008)
DNMTECHAS	No. of contacts of technical assistance	0.045*** (4.35)	-0.071*** (4.70)	0.020*** (2.60)	-0.023*** (2.25)
AGE	Age in years	-0.0041 (1.38)	0.0043 (1.34)	0.0036 (1.08)	-0.0073** (2.37)
EDCN	Years of schooling of farm head	0.019 (1.07)	0.023 (1.32)	0.019 (1.05)	0.010 (0.63)
DISTANCE	Distance to principal marketplace	-0.0037* (1.67)	-0.00039 (0.17)	0.0053** (2.31)	-0.0027 (1.19)
ARABLE	Arable land on farm	-0.00077 (0.54)	-0.00033 (0.23)	-0.00041 (0.26)	0.00054 (0.41)
CORNFLA	Proportion of farmland dedicated to corn	-0.29* (1.84)	-0.53*** (3.26)	0.14 (0.84)	-0.49*** (3.17)
CORNCREDIT	Amount of corn credit from BANDESA	0.00074*** (2.99)	-0.00041** (2.06)	0.00024 (1.15)	0.0010*** (4.62)
	Bivariate interactions				
DURFERT	1 if fertilizer or urea was used; 0 if not		0.15*** (3.34)	0.50*** (9.14)	0.093** (2.15)
DMACH	1 if machinery was used; 0 if not	0.15*** (3.22)		0.23*** (5.19)	0.12*** (2.82)
OINSECT	1 if insecticides were used; 0 if not	0.50*** (9.14)	0.23*** (5.40)		0.19*** (4.20)
OIMPSEED	1 if insecticides were used; 0 if not	0.94** (2.15)	0.12*** (3.95)	0.19*** (4.20)	
CONSTANT		1.28	-0.85	-1.38	-0.60

[a]Values of the asymptotic t-ratio are shown in parenthesis below each coefficient.

*Significant at 10 percent level.

**Significant at 5 percent level.

***Significant at 1 percent level.

The evidence presented in Table 27 confirms expectations regarding the relationship between education and modern input use. The four education coefficients are positive as expected, but statistical significance is low in all cases.

The estimated effect of age upon the use of the four inputs varies, with age positively related to insecticide and machinery use and negatively related to the use of fertilizer and improved seed. Nevertheless, the only statistically significant effect estimated is the negative one with respect to the use of improved seeds, suggesting that the reticence effect of age upon the use of this input predominates.

From Table 27 it may be seen that the only distance-to-market coefficient estimated with a reasonable degree of precision is that which estimates its impact upon the use of insecticides. But this coefficient is estimated to be positive. No explanation for this peculiar result is offered. It should be realized, however, that the measure of distance employed is subject to limitations. In particular, it is limited by the fact that interregional differences in market accessibility can dramatically alter the meaning of a given number of miles.

The amount of arable land on the farm does not appear to make any difference in whether or not modern inputs are used.

The relative importance of corn, on the other hand, appears to exert a statistically reliable negative influence upon the use of fertilizer, improved seeds and machinery. This result tends to confirm expectations that cultural and economic factors associated with subsistence agriculture, as reflected in a larger proportion of farm land used to produce corn, works against modern input adoption.

The significance of interactions between the use of the various inputs can hardly be questioned (Table 27). All of the six interaction terms are estimated with a high degree of statistical significance. The most important interactions appear to be between the use of insecticides and the use of each of the other inputs. Thus, insecticides appear to be the more modern of the four inputs in the sense that it is the least likely to be found used by itself in a farm.

It is interesting to verify from Table 27 that regional differences in modern input use persist after adjusting for a number of determining factors. Further, the level of asymptotic significance with which these regional coefficients are estimated is low in most instances. Thus, with the possible exception of the difference in insecticide use between Regions I and VI, the estimated differences are so large that they should not be attributed to chance.

What are the fundamental reasons behind these regional differences? No doubt they reflect, in part, agronomic differences among the regions. The use of fertilizer is more frequent in Regions I and VI where soils tend to be poor. By contrast, use of insecticides is more frequent in the South Coast where moisture and heat make it more susceptible to pests. Aside from agronomic reasons, the degree of commercialization may imply a regional disparity in the information at the disposal of farmers which, in turn, will affect their cultural practices.

Finally, an interregional difference in the price paid for an input might give rise to a difference in the frequency of use. There is considerable evidence that these regional disparities exist. In Table 28, the regression coefficients estimated for five input price equations are given. Each of these prices--corn seeds, urea, fertilizer, labor and

Table 28. Price equations[a]

Variables		Coefficients determining the price of				
Code	Description	Seeds	Uree	Fertilizer	Wages	Animal power
DBANDESA	1 if BANDESA; 0 if not	-1.51048 (0.65)	-0.00819* (1.89)	0.02362 (0.48)	0.05080*** (2.83)	0.02718 (0.22)
DREG3	1 if in Region III; 0 if not	8.45315 (0.77)	0.00009 (0.00)	0.00325 (0.03)	0.15436*** (3.40)	-0.58975 (1.32)
DREG4	1 if in Region IV; 0 if not	17.76814*** (2.58)	0.02177*** (3.66)	-0.00303 (0.04)	0.43904*** (15.35)	1.27335*** -(5.33)
DREG5	1 if in Region V; 0 if not	10.14751 (1.47)	0.00655 (1.09)	0.09774 (1.55)	0.006648** (2.53)	1.23334*** (5.72)
DREG5	1 if in Region VI; 0 if not	10.98555 (1.53)	0.0065 (0.11)	0.00830 (0.13)	0.09254*** (3.02)	0.42914** (2.00)
OIMPSEEO	1 if improved seeds; 0 if not	16.50013*** (6.44)				
DSIZE	1 if amount of areble lend > 10 ha; 0 if not	-0.43228 (0.18)	0.00581 (1.26)	-0.03933 (0.7)	0.05128** (2.54)	-0.14339 (0.96)
CONSTANT		13.27483	0.12874	0.11467	3.71857	1.44246
F		9.88***	3.52*	0.67	60.13***	11.67***
R^2		0.184	0.089	0.007	0.29529	0.21946
No. of observations		315	222	562	868	256

[a]Values of the t-statistic ere shown in parenthesis below each coefficient.

*Significant at 10 percent laval.

**Significant at 5 percent level.

***Significent et 1 percent laval.

animal power--is expressed as a function of a set of regional variables, a simple two-way classification of farm size (greater or less than 10 hectares) and the BANDESA status of the farmer. For each of the five prices considered, the regionalization scheme appears to be statistically meaningful.

It should be noted that these differences in input prices can hardly be explained in terms of a perfectly competitive market setting. They are better understood within the Guatemalan context by noting the high costs of transport, public interventions in these markets and differences in the cost of living between the coastal and highland regions.

The regressions in Table 28 are also informative insofar as the credit category is concerned. No difference by BANDESA status can be detected with respect to the prices of seeds, fertilizer or animal power. Nevertheless, participation in the BANDESA program appears to allow some farmers to obtain urea at a lower price. On balance, however, BANDESA farmers seem to have paid high wages.

The results presented in Table 27 shed considerable light regarding H1 and H4. Insofar as fertilizer is concerned, there can be little doubt that all aspects associated with participation in the SCSG promoted its use. This is perceived with considerable statistical reliability. Simple participation in the BANDESA credit program, perhaps by enabling the farmer to purchase urea at a cheaper price, induced him to use this modern input. Increasing amounts of credit for corn production further enhanced the chances that a farmer used fertilizer, perhaps as a result of its being included in credit work plans or through the procedure of disbursing part of the credit granted in the form of chits for fertilizer purchase. Moreover, repeated contact with

the extension agent for the purpose of enhancing a farmer's productivity in corn further induced the farmer to use fertilizer.

The results for insecticide use also lend credence to the notion that their use was being promoted by the SCSG. The statistical reliability in this instance, however, is not as definite as would be desirable. Contrary to H1, credit does appear to have induced insecticide use. This is particularly true when participation in the BANDESA credit program was combined with a substantial amount of corn specific credit. Also, contrary to H4, there is reliable statistical evidence supporting the notion that with increased contacts of technical assistance on corn, the probability of a farmer using insecticides was enhanced.

Results are somewhat mixed with regard to the use of improved seeds. Simple participation in the BANDESA credit program appears to have been insufficient to promote their use. With additional working capital provided for use in corn production, the probability of use of improved seeds was enhanced as suggested by the theory developed in Chapter II. Agricultural promoters, however, seem to have been recommending against the use of improved seeds. The latter result would tend to support the opinion of some experts who point to the confusion that has often been observed in Guatemala regarding the existence of a new technology. But, the opposing efforts of corn specific credit and technical assistance would suggest a significant failure to coordinate their recommendations on the part of BANDESA's credit agents and DIGESA's technical promoters.

Was the thrust of the credit program and the technical advice with respect to modern input use regionally differentiated? In Guatemala, what is reasonable for one region may be unreasonable for another, given

the existing interregional differences in human capital and natural resources. Presumably, the regionalization scheme chosen should capture some of the wide disparities across regional boundaries. The multivariate logit estimates, however, do not allow for a possible interaction effect between regions, technical assistance and credit. In Table 29 the extent to which a categorization of the data allows detection of these interaction effects is explored. While there is a substantial "thinning" of the information as the number of observations with which comparisons can be made is reduced, the previous conclusions persist.

In Regions I, III-IV and V, the general thrust of extension agents' advice with regard to improved seeds seems to have been against their use. In Region VI, the evidence, if anything, points in another direction. For the two BANDESA categories, the proportion of improved seeds use is higher among those with some technical assistance. The converse is true among non-BANDESA.

The previously detected positive influence of corn specific credit upon the use of improved seeds is also corroborated in Table 29 from a comparison between the BANDESA group who received credit on some other crop and with non-BANDESA.

The SCSG seems to have had more unity of purpose with regard to the use of farm machinery. In general, participation in the SCSG reduced the chances that a farmer would make use of farm machinery. Participation in the BANDESA credit program, corn specific credit and technical assistance, all worked against the adoption of farm machinery; and these results were obtained with a high degree of statistical reliability. Indeed, the institutional constraints upon the use of the credit

Table 29. Proportion of sample observations using improved corn seeds by BANDESA status, corn specific credit status and whether technical assistance on corn was provided, within regions

Region	BANDESA: Credit on other crop — Without assistance using improved	BANDESA: Credit on other crop — With some assistance using improved	BANDESA: Corn credit — Without assistance using improved	BANDESA: Corn credit — With some assistance using improved
I. Central Highlands	(3/51=).05	(0/8=)0	(5/36=).14	(0/10=)0
III-IV. South Coast (West and East)	(8/22=).36	(0/1=)0	(69/117=).59	(7/9=).78
V. Northeast	(18/65=).28	(2/9=).22	(52/89=).58	(5/26=).19
VI. Southeast Highlands	(7/25=).28	(4/9=).44	(15/27=).55	(22/34=).66

Table 29. Extended.

Region	Non-BANDESA		All credit categories	
	Without assistance using improved	With some assistance using improved	Without assistance using improved	With some assistance using improved
I. Central Highlands	(7/111=).06	(0/27=)0	(15/198=).07	(0/45=)0
III-IV. South Coast (West and East)	(43/120=).36	(3/36=).08	(120/398=).30	(10/46=).21
V. Northeast	(37/139=).27	(5/36=).14	(107/293=).36	(12/71=).17
VI. Southeast Highlands	(25/54=).46	(20/55=).36	(47/106=).44	(46/98=).47

appears to have been stronger in deterring the use of machinery than the inducement to its use provided by increased availability of working capital at reduced interest rates.

For the purpose of exploring the categorical sensitivity of the latter result, utilization rates have been estimated by region and technical assistance in Table 30. The negative relationship between technical assistance and machinery use appears to hold in all of the four regions considered. Differences in machinery use rates between the two technical assistance categories are almost nil in the coast where land is most flat and machinery use most predominant.

Examples Illustrative of the Implications of the Results

Explicit consideration of variables like education and age in the study of modern input utilization occasions an excellent opportunity to compare the effectiveness of the "traditional" factors with that of the SCSG in attaining an intermediate objective of utmost importance. The evidence indicates that, in order to change the odds of using fertilizers equivalent to that related to simple participation in the BANDESA program, the farmer would need to obtain 20 years of education. This quantitative difference is in part an outcome of the rather strict assumptions underlying the fitted model. Nevertheless, taken as a gross estimate, it does reflect the remarkable success which the BANDESA program has had in the promotion of the use of fertilizer.

A comparison between the effects of credit and age on the use of improved seeds is also illustrative. In order to obtain a change in the odds of use of this input which compensates for the detrimental effect of a difference in age of 14 years, Q100 of credit would suffice.

Table 30. Percent of sample farms that used machinery, by region and technical assistance

Region	Number of technical assistance Contacts > 0		Number of technical assistance Contacts = 0	
	Percent	Number[a]	Percent	Number[a]
I. Central Highlands	2.2	45	10.1	188
III-IV. South Coast (West and East)	54.3	37	56.0	259
V. Northeast	14.0	71	32.8	293
VI. Southeast Highlands	0	88	27.5	116

[a]Number of observations in sample.

The differences in emphasis of both kinds of assistance upon the use of fertilizers and insecticides is significant. To obtain a BANDESA-status-equivalent change in the probability of fertilizer use, approximately 12 contacts of technical assistance on corn are required. But, only two such contacts are required to obtain a similar change in the probability of insecticide use. If BANDESA participation were accompanied by Q200 of corn credit, four contracts of technical assistance would be the number required.

In Table 31, the implications of differing "doses" of credit and technical assistance upon the probability of use of all of the combinations of modern inputs possible are illustrated. For each combination of inputs (w, x, y, z) where

w	=	1	if fertilizers are used
	=	0	if not;
x	=	1	if insecticides are used
	=	0	if not;
y	=	1	if improved seeds are used
	=	0	if not; and
z	=	1	if machinery is used
	=	0	if not

the probability of use, P(w, x, y, z), is given for a farmer in Region I under the assumption that the remaining factors (e.g., age, education, etc.) take the mean sample values.

The most dramatic change which occurs with increments in the assistance dosage lies in the absolute decrease in the dependence upon a

Table 31. Probability of use of all possible combinations of modern inputs estimated for a farmer in Region I, who has the sample mean[a] value for age, education, distance, size of farm and relative importance of corn, under alternative conditions of assistance status

Input combinations[b]	Non-BANDESA		BANDESA			
			Corn credit = 0		Corn credit = 200	
	Technical assistance=0	Technical assistance=8	Technical assistance=0	Technical assistance=8	Technical assistance=0	Technical assistance=8
P(1,1,1,1)	0.0055	0.0033	0.0089	0.0044	0.0183	0.0088
P(0,1,1,1)	0.0010	0.0003	0.0006	0.0001	0.0009	0.0002
P(1,0,1,1)	0.0068	0.0030	0.0099	0.0035	0.0184	0.0064
P(0,0,1,1)	0.0094	0.0020	0.0046	0.0008	0.0064	0.0011
P(1,1,0,1)	0.0287	0.0254	0.0470	0.0333	0.0631	0.0442
P(0,1,0,1)	0.0078	0.0033	0.0043	0.0015	0.0043	0.0015
P(1,0,0,1)	0.0757	0.0483	0.1105	0.0564	0.1347	0.0680
P(0,0,0,1)	0.1535	0.0474	0.0756	0.0187	0.0685	0.0167
P(1,1,1,0)	0.0024	0.0046	0.0056	0.0085	0.0097	0.0146
P(0,1,1,0)	0.0008	0.0008	0.0006	0.0005	0.0008	0.0006
P(1,0,1,0)	0.0076	0.0104	0.0158	0.0174	0.0249	0.0270
P(0,0,1,0)	0.0195	0.0129	0.0137	0.0073	0.0160	0.0084
P(1,1,0,0)	0.0204	0.0563	0.0477	0.1054	0.0544	0.1187
P(0,1,0,0)	0.0102	0.0137	0.0081	0.0086	0.0068	0.0072
P(1,0,0,0)	0.1373	0.2735	0.2861	0.4557	0.2956	0.4654
P(0,0,0,0)	0.5134	0.4948	0.3609	0.2781	0.2771	0.2111

[a]Age = 44.26 years; education = 1.94 years; distance = 12.4 kilometers; size of farm = 11.11 hectares and relative importance of corn = 0.62.

[b]Fertilizer, insecticides, improved seeds, machinery, respectively.

basic technology, i.e., in P(0, 0, 0, 0). The probability that a non-BANDESA farmer without assistance--and with the mentioned characteristics--does not use any of the modern inputs is estimated to be close to 0.51. This probability gradually decreases with increases in assistance of all kinds. That is, it is a consequence of BANDESA participation, corn credit and technical assistance. Ultimately, for a BANDESA farmer receiving Q200 of corn credit and eight contacts of technical assistance on corn, P(0, 0, 0, 0) = 0.2111.

The major counterpart of this reduction in the probability of zero use of modern inputs is the increment in the probability of using only fertilizers, P(1, 0, 0, 0), as assistance increases. Again, the three kinds of assistance gradually affect the probability change, from 0.1373 for the non-BANDESA, no assistance case, to 0.4654 corresponding to the BANDESA farmer with Q200 corn credit and eight contacts with the extension agent.

CHAPTER V
PRODUCTION EFFICIENCY

The fundamental lesson to be learned from the preceding chapter is that the SCSG was successful in effecting changes in the kinds of agricultural inputs used by participating farmers. Through the selective promotion of certain key inputs, such as fertilizers and insecticides, BANDESA agents and DIGESA's promoters were successful in modernizing the agricultural practices of SCSG to include the use of these as well as related inputs, such as improved seeds and machinery.

The unresolved paradox is that, despite their apparent success, the net effect upon corn yields of BANDESA farmers was nil. In the present chapter, explanations of these perplexing results are sought by verifying the empirical validity of the following hypotheses:

H2: A technology making effective use of selected modern inputs did not exist.

H3: The levels of productivity attained by BANDESA credit farmers using the recommended technologies were lower than their full potential.

H5: DIGESA's promoters were unsuccessful in improving the technical efficiency of the farmers they attended.

The chapter is divided into three main sections. First, the principal assumptions on which the statistical analysis of agricultural production rests are made explicit. Second, an outline of the regression estimates, including a description of the variables and procedures

used to test H2, H3, and H5, is provided. The chapter concludes with a presentation and discussion of the results obtained.

An Econometric Model of Within-Technology Choice of Input Quantities

A model of a farmer's production behavior was developed in Chapter II. The principal concern of that model was the farmer's choice among technologies in which different kinds of inputs were used. As a matter of course, input quantities within the chosen technology were also determined. In order to isolate the importance of a capital constraint in the selection of a technology, the model assumed that choices were made within a certain environment in which the farmer had perfect knowledge of production relationships and of input and output prices. Under a competitive setting and in the long run, as farmers saved and a lack of capital no longer prevented them from producing optimum output, all farms would, in equilibrium, produce the same level of output and use the same quantities and kinds of inputs provided they had similar natural resource bases.

In practice, significant variations in input use are observed among Guatemalan farmers, not only as to the kinds of inputs used, but also with regard to the quantities in which they are used. These variations are too substantial to be fully explained in terms of a long process of adjustment towards an equilibrium not yet reached. Moreover, it is doubtful whether farmers have the complete knowledge of output prices and production relationships assumed (for purposes of simplicity) in Chapter II. The SCSG itself recognized ignorance on the part of farmers concerning technological innovations and included technical assistance

as an important part of the system in an attempt to improve farmers' knowledge of production relationships. Among other things, differences among farmers in land qualities and water availability very likely cause differences in yield response to other inputs.

In order to verify the empirical validity of H2, H3 and H5, a model of within-technology choice of input quantities is developed here. The model expands on the one presented in Chapter II in that production decisions are assumed to be made within an uncertain environment. The plausible assumptions on which the model is based allow the estimation of production surfaces from observable quantities of inputs used and output produced by Guatemalan farmers.

Capital Inputs

Many studies of agricultural production employ a composite index of aggregated capital expenditures as a measure of the capital input. This procedure is appropriate only to the extent that the differences in the prices of the capital flows adequately reflect differences in quality between inputs. That is, if, for example, one dollar of expenditure in fertilizer brings forth the same amount of output as one dollar of expenditure in, say, insecticides.

Such an approach is inadequate if, as is the case in the present study, what needs to be determined is whether the application of a qualitatively different input makes a significant difference in the production of corn. For then, the interaction among inputs might entail changes in productivities which could not be detected through a composite capital index.

The approach adopted here consists of fitting different production surfaces which depend upon the presence or absence of inputs in the production process. In so doing, explicit account is taken of the differences in the services which flow from the use of qualitatively different capital goods. These differences may reflect social as well as economic aspects of productivity. That is, the same farmer may be more productive using machinery than not using it, but the use of machinery is often accompanied by a set of cultural and agronomic practices which may themselves have an effect on productivity.

Functional Form

The Cobb-Douglas production function has been chosen to describe the individual surfaces. The unitary elasticity of substitution which characterizes it is a disturbing feature. Nevertheless, other commonly used functions, such as the CES, are difficult to estimate when more than two inputs are considered. Ease of handling, generally good fit and separability of the contribution to output of individual inputs are reasons for the use of the Cobb-Douglas form in the present study.

The Model

Early studies which sought to estimate Cobb-Douglas production relationships using cross section observations of firms within an industry often ignored the problems in interpretation which their estimates posed. A "simultaneous equation bias" results from ordinary least squares regression of observed input quantities on output, since profit maximizing firms jointly determine these variables as part of their decision making processes. A good exposition of this problem may be

found in Malinvaud [1970] and in Timmer [1970]. A complete list of the earlier studies may be found in Marschak and Andrews [1944]. There and in Nerlove [1965], the problem is circumvented by concentrating on industries under purely private control and specifying the market imperfections which determine such control.

Hoch [1958] suggested that a farmer may be maximizing profits on the basis of "anticipated output," but this notion was left undeveloped. Mundlak and Hoch [1965] consider a statistical specification in which ordinary least squares regression of inputs on output yields unbiased estimates because either firms do not maximize profits or because the production function is non-stochastic. Though akin to the specification used by Mundlak and Hoch [1965] from a statistical standpoint, the economic framework employed in the present study closely follows that of Zellner et al. [1966]. Subsequent work by Hodges [1969] has shown their results to be applicable also under a CES specification of production relationship. Moreover, Blair and Lusky [1975] have shown that even where farmers are non-neutral in their behavior toward risk, the framework used here may be used to estimate unbiased and consistent estimates of Cobb-Douglas production function parameters.

Consider the case in which one basic input, X_1, is widely used among all farmers, whereas three other inputs, X_2, X_3 and X_4, are used by some but not all farmers in the production of output Y. Following Zellner et al. [1966], let production be a stochastic function of the inputs used. Then, for the i^{th} farmer, the relationship between the quantities of inputs used and the output he will produce will be given by one of the following surfaces, depending upon the combination of inputs he uses:

$$Y_i = AX_{1i}^{\alpha_1} e^{u_{0i}} \quad \text{for } X_{2i} = X_{3i} = X_{4i} = 0 \quad \text{and } X_{1i} > 0$$

$$Y_i = BX_{1i}^{\beta_1} X_{2i}^{\beta_2} e^{u_{0i}} \quad \text{for } X_{3i} = X_{4i} = 0 \quad \text{and } X_{1i}, X_{2i} > 0$$

$$Y_i = CX_{1i}^{\gamma_1} X_{3i}^{\gamma_3} e^{u_{0i}} \quad \text{for } X_{2i} = X_{4i} = 0 \quad \text{and } X_{1i}, X_{3i} > 0$$

$$Y_i = DX_{1i}^{\delta_1} X_{4i}^{\delta_4} e^{u_{0i}} \quad \text{for } X_{2i} = X_{3i} = 0 \quad \text{and } X_{1i}, X_{4i} > 0 \qquad (15)$$

$$Y_i = EX_{1i}^{\theta_1} X_{2i}^{\theta_2} X_{3i}^{\theta_3} e^{u_{0i}} \quad \text{for } X_{4i} = 0 \quad \text{and } X_{1i}, X_{2i}, X_{3i} > 0$$

$$Y_i = FX_{1i}^{\phi_1} X_{2i}^{\phi_2} X_{4i}^{\phi_4} e^{u_{0i}} \quad \text{for } X_{3i} = 0 \quad \text{and } X_{1i}, X_{2i}, X_{4i} > 0$$

$$Y_i = GX_{1i}^{\mu_1} X_{3i}^{\mu_3} X_{4i}^{\mu_4} e^{u_{0i}} \quad \text{for } X_{2i} = 0 \quad \text{and } X_{1i}, X_{3i}, X_{4i} > 0$$

$$Y_i = HX_{1i}^{\Omega_1} X_{2i}^{\Omega_2} X_{3i}^{\Omega_3} X_{4i}^{\Omega_4} e^{u_{0i}} \quad \text{for } X_{1i}, X_{2i}, X_{3i}, X_{4i} > 0$$

where u_{0i} is a normally distributed random disturbance with zero mean reflecting variations in ouptut related to changes in weather conditions beyond the control of the farmer and making their effect felt after decisions on input use have been made. In particular, it is assumed that $u_{0i} \sim N(0, \sigma_{00})$.

The second surface in (15) may be used to illustrate a farmer's within-technology choice of input quantities. It is reasonable to assume that the prices of inputs are known with certainty by the farmer at the time in which he makes his decisions regarding choice and quantities of inputs. In the face of uncertainty about the actual quantities of output he will produce and about the price he will get for his output in the marketplace, the farmer will attempt to maximize his expected

profits; i.e.,

$$\max E(\pi) = p_i^+ E(Y_i) - p_1 x_1 - p_2 x_2 \tag{16}$$

In (16), p_i^+ is the price which the i^{th} farmer expects to receive for his output at the time of sale; p_1 and p_2 are the prices of the two inputs used in the production process. E(Y) is the expected value of output and is given by[1]

$$\begin{aligned} E(Y_i) &= BX_{1i}^{\beta_1} X_{2i}^{\beta_2} E(e^{u_{0i}}) \\ &= BX_{1i}^{\beta_1} X_{2i}^{\beta_2} e^{\sigma_{00}/2} \end{aligned} \tag{17}$$

In trying to maximize his expected profits, the farmer will try to set the expected value of the marginal production of each of his inputs to its price; i.e., to set

$$p_i^+ \left[\frac{E(Y_i) \cdot \beta_k}{X_{ki}} \right] = p_k \qquad \text{for } k = 1, 2 \tag{18}$$

---

[1]By definition,

$$E(e^{u_{0i}}) = \int_{-\infty}^{\infty} e^{u_{0i}} \frac{1}{\sqrt{2\pi\sigma_{00}}} \exp\left[-u_{0i}^2/2\sigma_{00} \right] du_{0i}$$

Following Hogg and Craig [1970, p. 105], let $u_{0i} = \sqrt{\sigma_{00}}\, y + \sigma_{00}$. Then, $du_{0i} = \sqrt{\sigma_{00}}\, dy$, and

$$\begin{aligned} E(e^{u_{0i}}) &= \int_{-\infty}^{\infty} e^{\sqrt{\sigma_{00}}\, y + \sigma_{00}} \frac{1}{\sqrt{2\pi\sigma_{00}}} \exp \frac{-(\sqrt{\sigma_{00}}\, y + \sigma_{00})^2}{2\sigma_{00}} \sqrt{\sigma_{00}}\, dy \\ &= \exp \frac{\sigma_{00}}{2} \int_{-\infty}^{\infty} \frac{1}{\sqrt{2\pi}} e^{-y^2/2}\, dy \\ &= \exp \frac{\sigma_{00}}{2}. \end{aligned}$$

It should be noted that p_i^+ is a constant to the i^{th} farm but a variable across farms. That is, there is a distribution of output price expectations across farms which may be assumed to be related to the competitive market price, p, which will be realized by all farms at the time of sale, as follows:

$$p_i^+ = p\, e^{-v_{0i}^*} \qquad (19)$$

where v_{0i}^* is a random variable.

From (15), (17) and (19) it may be seen that the optimizing condition in (18) which the farmer will try to meet, is equivalent to

$$p\, e^{-v_{0i}^*} \left[\frac{Yi\; e^{\sigma_{00}/2}}{e^{u_{0i}}} \cdot \frac{\beta_k}{X_{ki}} \right] = p_k \qquad \text{for } k = 1, 2 \qquad (20)$$

In practice, however, the farmer is bound to make mistakes as he tries to meet this condition. The relationship that will, in fact, hold is

$$p\, e^{-v_{0i}^*} \left[\frac{Yi\; e^{\sigma_{00}/2}}{e^{u_{0i}}} \cdot \frac{\beta_k}{X_{ki}} \right] = p_k\, e^{v_{ki}^*} \qquad (21)$$

$$\text{for } k = 1, 2$$

where the v_{ki}^*, k = 1, 2 are random disturbances which account for managerial inertia, ignorance, etc., and which prevent the farmer from making optimal decisions.

The v_{ki}^* (k = 0, 1, 2) are independent from u_{0i}. The latter disturbance is the result of changes in weather conditions and other factors beyond the control of the farmer. On the other hand, the v_{ki}^* are dependent upon the particular idiosyncracies of each farmer. It is

human factors, rather than natural or unexpected factors, that determine variations in farmers' expectations regarding output price, i.e., the v_{0i}^{*}. Human factors are also assumed to account for the mistakes of farmers, represented by v_{1i}^{*} and v_{2i}^{*}, as they try to meet the optimizing conditions.

The production model of within-technology choice of input quantities for the second surface in (15) may be written in the logarithms of the observable variables as follows:

$$y_i - \beta_1 x_{1i} - \beta_2 x_{2i} = m_0 + u_{0i} \tag{22}$$

$$y_i - x_{1i} = m_1 + u_{0i} + v_{1i} \tag{23}$$

$$y_i - x_{2i} = m_2 + u_{0i} + v_{2i} \tag{24}$$

where

$$y_i = \ln Y_i,$$

$$x_{1i} = \ln X_{1i},$$

$$x_{2i} = \ln X_{2i},$$

$$m_0 = \ln B,$$

$$m_1 = \ln\left[\frac{p_1}{p \cdot \beta_1}\right] - \sigma_{00/2},$$

$$m_2 = \ln\left[\frac{p_2}{p \cdot \beta_2}\right] - \sigma_{00/2},$$

$$v_{1i} = v_{0i}^{*} + v_{1i}^{*} \text{ and}$$

$$v_{2i} = v_{0i}^{*} + v_{2i}^{*}.$$

The reduced form equations for the model are given by

$$y_i = \frac{m_0 + u_{0i} - \beta_2(m_2 + u_{0i} + v_{2i}) - \beta_1(m_1 + u_{0i} + v_{1i})}{1 - \beta_2 - \beta_1} \quad (25)$$

$$x_{1i} = \frac{m_0 - m_1 - v_{1i} + \beta_2(m_1 - m_2 + v_{1i} - v_{2i})}{1 - \beta_2 - \beta_1} \quad (26)$$

$$x_{2i} = \frac{m_0 - m_2 - v_{2i} + \beta_1(m_2 - m_1 + v_{2i} - v_{1i})}{1 - \beta_2 - \beta_1} \quad (27)$$

From (26) and (27) it may be seen that x_{1i} and x_{2i} do not depend on u_{0i}. Since u_{0i} is independently determined from either v_{1i} of v_{2i}, equation (22) may be used to obtain the ordinary least squares estimator of β_1, β_2, and B which are consistent and unbiased [Zellner et al., 1966, p. 789].

Regression Specifications

Model A

As given in equation (15), the model requires the estimation of 28 parameters. Furthermore, as the model is expanded to consider additional inputs, which may or may not be present in production processes, the number of parameters increases rapidly.

The most straightforward method of estimation of equation (15) is to segment the sample according to the constellation of non-basic inputs used in production and to estimate each function separately. The first set of regression specifications reported here (Model A) follows this procedure.

The amount of information that can be obtained through such a segmentation of the sample, however, is limited. On one hand, while a production function using a particular input combination may theoretically exist, it may, in fact, not be used or only infrequently used. In Table 32, the estimated number of BANDESA and non-BANDESA corn fields in Guatemala in which the various combinations of the modern inputs were used--fertilizer, insecticide, improved corn seed and machinery--in addition to the basic inputs--land, labor and traditional seeds--is provided. For example, whereas there are many possible output variations that could be obtained from using different quantities of insecticides, improved seeds and the basic inputs, in practice only an estimated 0.6 percent of all Guatemalan farmers used such a combination of inputs.[2]

The second problem in the separate estimation by technology is the existence of a general multicollinearity among inputs within the technologies for which a few observations are available. Given that prices will be close together within regions and that technologies tend to be region specific, variations in price expectations and managerial ability among farmers within the same region may be insufficient to produce the variability of input use required to obtain separate estimates of the output coefficients within given technologies.[3] Accordingly, Model A, being somewhat unrestricted as to functional form, does not permit much

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[2]Given the limited number of observations on which this estimate is based, it should be subject to a large variance. Here it is used only for the purpose of illustration.

[3]See Doll [1974] for a detailed discussion of multicollinearity.

Table 32. Estimated number of corn fields in the population, which used specified combinations of inputs, by credit type

Inputs	Non-BANDESA				BANDESA				Total	
	Number	Percent of			Number	Percent of				
		Row	Column	Total		Row	Column	Total	Number	Percent
Basic	1389	78.6	31.7	16.4	378	21.4	9.3	4.5	1767	20.9
Fertilizer	823	42.4	18.8	9.7	1118	57.6	27.5	13.2	1941	22.9
Fert./improved seed	309	46.3	7.0	3.7	358	53.7	8.8	4.2	667	7.9
Fert./mach./imp. seed/ insect.	120	21.6	2.8	1.4	436	78.4	10.7	5.2	556	6.6
Fert./insectidice	186	37.2	4.2	2.2	314	62.8	7.7	3.7	500	5.9
Fert./imp. seed/insect.	187	43.4	4.3	2.2	244	56.6	6.0	2.9	431	5.1
Machinery	276	67.6	6.3	3.3	132	32.4	3.3	1.6	408	4.8
Fert./mach./insect.	105	29.2	2.4	1.2	254	70.8	6.2	3.0	359	4.2
Mach./insect.	229	68.4	5.2	2.7	106	31.6	2.6	1.2	335	4.0
Mach./imp. seed/insect.	128	39.5	2.9	1.5	196	60.5	4.8	2.3	324	3.8
Improved seed	199	64.4	4.5	2.4	110	35.6	2.7	1.3	309	3.7
Fert./machinery	90	31.4	2.1	1.1	197	68.6	4.8	2.3	287	3.4
Fert./mach./imp. seed	124	47.5	2.8	1.5	137	52.5	3.4	1.6	261	3.1
Mach./imp. seed	97	70.3	2.2	1.1	41	29.7	1.0	0.5	138	1.6
Insecticide	107	85.6	2.4	1.3	18	14.4	0.4	0.2	125	1.5
Imp. seed/insect.	18	34.6	0.4	0.2	34	65.4	0.8	0.4	52	0.6
TOTAL	4387	51.9	100.0	51.9	4073	48.1	100.0	48.1	8460	100.0

experimentation with the available data regarding the number of variables which may be included in the regression equations.

To try to determine the empirical validity of H2, technologies have been defined in this model in terms of the combination of four of the non-basic inputs employed by the farmer: animal power, fertilizer, insecticides and machinery. Each of these variables has been made to enter the equation for technologies which use them in terms of the logarithm of the quantities used (i.e., DLNFERTILIZER, DLNINSECTICIDES, DLNMACHINERY, DLNAIMPOWER). Also, an attempt has been made to capture the effects of using improved corn seeds instead of well known "local" varieties, but only in terms of a multiplicative shifter of the response function (i.e., DIMPSEED).

Variables which might have the effect of raising or lowering overall corn productivity have also been included, where the data allow, as adjusters of the multiplicative coefficient. The adjusters considered are those which try to capture land quality differences between the Western Highlands and the remaining regions (DREG3, DREG4, DREG5 and DREG6), and one which tries to detect any possible differences which arise from using a varying proportion of hired to total labor (LNHIRED).

To shed light on H3, an additional adjuster of the multiplicative term has been included in the regression equations to indicate the BANDESA status of the farmer (DBANDESA). Similarly, in reference to H4, a multiplicative shifter capturing effects on productivity related with having received some technical assistance (DTECHAS) is also included in the regression estimates in Model A.

Model B

The second set of regression estimates, Model B, recognizes the limitations posed by sample segmentation on account of the categorical and ordinal correlation in input use. To increase the statistical reliability of the estimated effects of variables pertinent to the testing of H2, H3 and H5, observations are pooled across technologies and estimated jointly under certain assumptions regarding equality of parameters across technologies.

To begin with, it was assumed that the multiplicative term remains constant across equations, i.e., that

$$A = B = C = D = E = F = G = H,$$

that the u_{0i} are normally distributed and that equality of variances across equations in (15) holds. Implicit in these assertions is the notion that the wider variability in output observed between BANDESA and non-BANDESA farmers [McDonald, 1975] is largely explained by differences in input use rather than in unexplained factors; i.e., by wider variability in the x_{ki} rather than in differences in σ_{00} between BANDESA and non-BANDESA farmers.[4]

Under these assumptions, the sample observations available from the SFBCS may be pooled together to estimate the common multiplicative term plus the remaining 20 parameters in (15). In log-linear terms (15) may be written as

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[4]There is some evidence that this is likely the case. For instance, the mean area planted to corn by BANDESA and non-BANDESA farmers are 3.68 and 2.84 hectares, respectively; and the ratio of sample mean variances of area planted to corn of BANDESA to non-BANDESA farms is equal to 3.39 [McDonald, 1975, p. 16].

$$y_i = \alpha_0 + (\alpha_1 + d_2\alpha_{12} + d_3\alpha_{13} + d_4\alpha_{14} + d_2d_3\alpha_{23} + d_2d_4\alpha_{24}$$

$$+ d_3d_4\alpha_{34} + d_2d_3d_4\alpha_{234})x_{1i}$$

$$+ (d_2\beta_2 + d_2d_3\beta_{23} + d_2d_4\beta_{24} + d_2d_3d_4\beta_{234})x_{2i}$$

$$+ (d_3\gamma_3 + d_2d_3\gamma_{23} + d_3d_4\gamma_{34} + d_2d_3d_4\gamma_{234})x_{3i}$$

$$+ (d_4\delta_4 + d_2d_4\delta_{24} + d_3d_4\delta_{34} + d_2d_3d_4\delta_{234})x_{4i}$$

$$+ u_{0i} \tag{28}$$

where

$$d_j = 1 \quad \text{if } X_{ji} > 0$$

$$= 0 \quad \text{if } X_{ji} = 0 \quad \text{for } j = 2, 3, 4.$$

From a comparison of (28) and (15) it may be seen that

$$\alpha_0 = \ln A$$

$$\beta_1 = \alpha_1 + \alpha_{12}$$

$$\gamma_1 = \alpha_1 + \alpha_{13}$$

$$\delta_1 = \alpha_1 + \alpha_{14}$$

$$\theta_1 = \alpha_1 + \alpha_{12} + \alpha_{13} + \alpha_{23}$$

$$\phi_1 = \alpha_1 + \alpha_{12} + \alpha_{14} + \alpha_{24}$$

$$\mu_1 = \alpha_1 + \alpha_{13} + \alpha_{14} + \alpha_{34}$$

$$\Omega_1 = \alpha_1 + \alpha_{12} + \alpha_{13} + \alpha_{14} + \alpha_{23} + \alpha_{24} + \alpha_{34} + \alpha_{234}$$

$$\beta_2 = \beta_2$$

$$\theta_2 = \beta_2 + \beta_{23}$$

$$\phi_2 = \beta_2 + \beta_{24}$$

$$\Omega_2 = \beta_2 + \beta_{23} + \beta_{24} + \beta_{234}$$

$$\gamma_3 = \gamma_3$$

$$\theta_3 = \gamma_3 + \gamma_{23}$$

$$\mu_3 = \gamma_3 + \gamma_{34}$$

$$\Omega_3 = \gamma_3 + \gamma_{23} + \gamma_{34} + \gamma_{234}$$

$$\delta_4 = \delta_4$$

$$\phi_4 = \delta_4 + \delta_{24}$$

$$\mu_4 = \delta_4 + \delta_{34}$$

$$\Omega_4 = \delta_4 + \delta_{24} + \delta_{34} + \delta_{234}$$

In practice, equation (28) still has many more parameters than variability in the data will allow to be estimated. Accordingly, the specification in Model B has incorporated additional parametric restrictions.

The inputs which receive explicit quantitative treatment in the regression specification, whenever they are found to have been used in the production process, are the three basic inputs--land (LNLAND), labor (LNLABOR) and seeds (LNSEEDS)--and four of the non-basic inputs--fertilizer (DLNFERTILIZER), insecticides (DLNINSECTICIDES), animal power (DLNANIMPOWER) and machinery (DLNMACHINERY). As in Model A, the impact of using improved corn seeds is measured in terms of shifts in the multiplicative term (i.e., through the coefficient of DIMPSEED).

Variations in the elasticities of the basic inputs associated with their combined use with the four non-basic inputs receiving quantitative treatment have been allowed. They are measured by the coefficients of DLNFERTL, DLNFERLA, DLNFERSE for the effect of fertilizer use upon the basic inputs' elasticities; by DLNINSTL, DLNINSLA, DLNINSSE for the effect of insecticides use upon the basic inputs' elasticities; by DLNMACHTL, DLNMACHLA, DLNMACHSE for the effect of machinery use upon the basic inputs' elasticities and by DLNANITL, DLNANILA, DLNANISE for the effect of animal power use upon the basic inputs' elasticities.

Nevertheless, in the regression specification, all interaction terms of higher order than two--i.e., α_{234}, β_{234}, γ_{234} and δ_{234}--are assumed to be equal to zero. Also, most two-way interaction terms are assumed to be equal to zero. The exceptions are terms which seek to capture the differences in the elasticities: (a) of machinery use which comes about as a result of using machinery in conjunction with insecticides (DLNINSMA), (b) of fertilizer use which comes about as a result of using fertilizers in conjunction with insecticides (DLNINSFE) and (c) of insecticide use which comes about as a result of using insecticides in conjunction with fertilizers (DLNFRIN).

The criteria for selecting the terms to be included in the equations are empirical, i.e., those interaction terms estimated to be significant in a set of regression specifications which gradually eliminate the higher order interaction terms from the estimation equation have been kept in the equation. In so doing, the expanded model, be it equation (15) or equation (28), is not being assumed away in favor of the models implicit in the regression specifications which eliminate higher order interaction terms. Instead, the presence of

multicollinearity is being acknowledged and no credibility is attached to estimates of the parameters of the variable inputs used. If a particular interaction term appears under this set of equations as significant, it could well be because it is detecting a surrogate effect for a higher order interaction which the variability of the data will not allow to be captured.

Nevertheless, the regression estimates of Model B are useful in the estimation of the global effects upon the multiplicative term of equation (28) of variables which directly affect the managerial capabilities of farmers. Accordingly, they provide for useful tests of H3 and H5 as a complement to those provided by Model A.[5] To do so, the variables introduced in the preceding chapter which try to capture the effect of participation in the BANDESA credit program (DBANDESA), of the amount of corn specific credit which the farmer receives (CORNCREDIT) and of the number of contacts of technical assistance related to corn which the farmer receives (DNMTECHAS) are also considered in the regression estimates with Model B to ascertain their effect upon production efficiency.

The pooling of observations across technologies in Model B, though it comes about as a result of restrictive assumptions concerning functional forms, permits a wider experimentation with the number of multiplicative shifters that can be included in the regression experiments. Such experimentation includes the consideration of (a) regional

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[5] It should be noted that the approach used in Model B is akin to that of Ulveling and Fletcher [1970]. The procedure used here also expands upon the Cobb-Douglas function in an attempt to account for technological differences. Their approach is continuous since a composite index of capital services is used. Instead, stepwise differences in production surfaces depending upon the use of the various capital flows are used here.

differences between the Western Highlands and the remaining regions (DREG3, DREG4, DREG5 and DREG6), (b) differences in land quality which were not captured by regional differences but that are related to the proportion of the farmer's total land which is rolling (ROLL) or broken (BROKN) as compared to flat land, (c) differences arising from dependence upon a higher proportion of family to total labor (LNFAMILY) and (d) differences in productivity associated with farm size, i.e., amount of ARABLE land in the farm.

Results[6]

Table 33 presents the results of the regression specifications and estimates with Model A. Table 34 presents the results of the regression specifications and estimates with Model B. The discussion is organized about the variables of interest.

Differences in corn productivity by farm size could potentially arise as a result of differences in technology employed or a result of

[6]The caveat made in Chapter I regarding the implications of the matching procedure used in drawing up the sample, upon the statistical inferences to be derived, should be regarded here. To the extent that the resulting dependence between BANDESA and non-BANDESA observations is related to factors which are not considered among the independent variables for the model, which are positively related across credit category for those sample observations which are interdependent, which are uncorrelated with the variables included in the regression equations and which help determine yield (this could be the case, for example, with intra-regional variations in land quality within the major regional groupings considered and which are distinct from the effect of the proportion of broken or rolling land to total land on farms), the estimate of the variances of the coefficients in Tables 33, 34 and 38 will be under their true value. Accordingly, the true levels of statistical significance (the probability of Type I error) would tend to be larger than would be indicated by the t values there reported on. (The problem discussed here is different but akin to that of autocorrelated disturbances discussed in Johnston [1972, pp. 246-249] and in Kmenta [1971, pp. 273-282].)

Table 33. Separate estimation of corn production functions by input combinations, Model A[a]

Variables		Coefficients				
Code	Description	Basic	Basic + fertilizer	Basic + Machinery	Basic + Animal power	Basic + Fertilizer + insecticides
LNSEEDS	ln (quantity of seeds used)	0.17080** (2.25)	0.25959*** (4.13)	0.17383 (1.59)	0.16634 (1.57)	0.19517** (2.02)
LNLAND	ln (size of field)	0.40016*** (4.13)	0.52804*** (6.76)	0.65781*** (5.49)	0.66545*** (4.26)	0.23687** (2.05)
LNLABOR	ln (total labor used on field)	0.40689*** (4.68)	-0.02818 (0.33)	0.14132* (1.74)	0.03272 (0.41)	0.34263*** (3.51)
DTECHAS	1 if No. of technical assistance contacts > 0; 0 if not	-0.13226 (1.06)	0.04944 (0.60)			-0.02542 (0.23)
DBANDESA	1 if BANDESA; 0 if not	-0.16428* (1.66)	0.01839 (0.22)	0.00659 (0.04)	0.02005 (0.09)	-0.15148 (1.10)
DIMPSEED	1 if improved seeds; 0 if not	0.20800* (1.77)	0.19889** (2.01)			0.14086 (1.08)
LNHIRED	ln (proportion hired to total labor)	-0.08084 (0.91)	0.05284 (0.77)			0.09727 (0.47)
DREG3	1 if in Region III; 0 if not	0.20861 (0.78)				0.20678 (0.65)
DREG4	1 if in Region IV; 0 if not	0.34020** (1.97)				0.21419 (1.20)
DREG5	1 if in Region V; 0 if not	0.23662* (1.65)				0.30072 (1.53)
DREG6	1 if in Region VI; 0 if not	0.12663 (0.68)				0.20201 (0.89)
DLNFERTILIZER	ln (fertilizer) if fertilizer > 0; 0 if not		0.24649*** (4.06)			0.28439*** (3.76)
DLNINSECTICIDES	ln (insecticides) if insecticides > 0; 0 if not					0.08966 (1.49)
DLNMACHINERY	ln (machinery) if machinery > 0; 0 if not			-0.09964* (1.94)		
DLNANIMPOWER	ln (animal power) if animal power > 0; 0 if not				0.05545 (0.42)	
CONSTANT		2.25389	2.93013	4.42924	4.09546	1.39457
F		35.72***	57.82***	23.65***	13.41***	43.04***
R^2		0.612	0.725	0.692	0.523	0.903
No. of BANDESA		88	111	16	10	49
No. of observations		261	184	43	67	74

[a] Values of the t-statistic are shown in parenthesis below each coefficient.

*Significant at 10 percent level.

**Significant at 5 percent level.

***Significant at 1 percent level

Table 33. Extended.

Variables		Coefficients			
Code	Description	Basic + Fertilizer + Animal power	Basic + Insecticides + Machinery	Basic + Fertilizer + Insecticides + Machinery	Basic + Fertilizer + Insecticides + Machinery + Animal power
LNSEEDS	ln (quantity of seeds used)	0.09975 (0.81)	0.15440 (0.66)	0.54453*** (3.00)	-0.18423 (1.18)
LNLAND	ln (size of field)	0.53074*** (4.61)	-0.15022 (0.39)	0.39132* (1.79)	0.15231 (0.51)
LNLABOR	ln (total labor used on field)	0.21512** (2.28)	0.51153** (2.36)	0.18725* (1.74)	0.29529* (1.82)
DTECHAS	1 if No. of technical assistance contacts > 0; 0 if not	-0.01431 (0.10)		0.48448** (2.14)	
DBANDESA	1 if BANDESA; 0 if not	-0.37042*** (3.23)	-0.42411* (1.76)	-0.39784** (2.04)	-0.39974* (1.82)
DIMPSEED	1 if improved seeds; 0 if not	0.05379 (0.45)		-0.21349 (1.32)	
LNHIRED	ln (proportion hired to total labor)	0.20427* (1.74)		-0.02059 (0.10)	
DREG3	1 if in Region III; 0 if not				
DREG4	1 if in Region IV; 0 if not				
DREG5	1 if in Region V; 0 if not				
DREG6	1 if in Region VI; 0 if not				
DLNFERTILIZER	ln(fertilizer) if fertilizer > 0; 0 if not	0.27503*** (2.97)		0.10367 (1.28)	0.59412*** (4.80)
DLNINSECTICIDES	ln (insecticides) if insecticides > 0; 0 if not		0.19485 (1.12)	0.06719 (0.63)	0.05407 (0.87)
DLNMACHINERY	ln (machinery) if machinery > 0; 0 if not		0.59472** (2.30)	-0.03765 (0.52)	0.42067** (2.42)
DLNANIMPOWER	ln (animal power) if animal power > 0; 0 if not	-0.03288 (0.48)			-0.08394 (0.55)
CONSTANT		2.73099	0.48089	2.27326	0.70114
F		29.33***	11.63***	17.39***	11.26***
R^2		0.763	0.636	0.725	0.709
No. of BANDESA		49	25	60	31
No. of observations		92	47	77	44

Table 34. Corn production functions, Model B[a]

Variables		Coefficients				
Code	Description	B-1	B-2	B-3	B-4	B-5
DNMTECHAS	No. of technical assistance contacts	0.0096** (2.48)	0.0105*** (2.74)	0.0100*** (2.64)	0.0098*** (2.58)	0.0101*** (2.65)
DBANDESA	1 if BANDESA; 0 if not	-0.2080*** (4.96)	-0.2114*** (5.12)	-0.2076*** (5.05)	-0.2066*** (5.04)	-0.2172*** (5.10)
CORNCREDIT	Amount of corn credit	0.0001* (1.76)	0.0001* (1.79)	0.0001* (1.71)	0.0001 (1.63)	0.001* (1.71)
DIMPSEED	1 if improved seeds; 0 if not	0.0747* (1.76)	0.0698* (1.67)	0.0809* (1.94)	0.0802* (1.93)	0.0803* (1.94)
DREG3	1 if in Region III; 0 if not	0.2390** (2.42)	0.1523 (1.55)	0.1876* (1.91)	0.1557 (1.58)	0.1582 (1.60)
DREG4	1 if in Region IV; 0 if not	0.1355* (1.82)	0.0795 (1.07)	0.0909 (1.23)	0.0881 (1.20)	0.0819 (1.11)
DREG5	1 if in Region V; 0 if not	0.1456** (2.35)	0.1175* (1.92)	0.1345** (2.19)	0.1273** (2.08)	0.1132* (1.81)
DREG6	1 if in Region VI; 0 if not	0.1318** (2.01)	0.1197* (1.86)	0.1278** (1.99)	0.1309** (2.04)	0.1252* (1.95)
BROKN	Proportion of land on farm which is broken		-0.3813*** (5.77)	-0.3934*** (5.97)	-0.3893*** (5.93)	-0.3923*** (5.95)
ROLL	Proportion of land on farm which is rolling		-0.2368*** (4.46)	-0.2419*** (4.57)	-0.2361*** (4.47)	-0.2382*** (4.50)
ARABLE	Amount of arable land on farm					0.0166 (0.68)
LNFAMILY	ln (proportion of family to total labor)					-0.0181 (1.01)
LNLAND	ln (size of field)	0.5831*** (11.86)	0.5799*** (11.99)	0.5708*** (11.8)	0.5670*** (11.75)	0.5529*** (10.63)
LNLABOR	ln (total labor used on field)	0.1840*** (4.38)	0.1951*** (4.71)	0.1886*** (4.57)	0.1849*** (4.50)	0.1756*** (4.19)
LNSEEDS	ln (quantity of seeds used)	0.2189*** (4.79)	0.2120*** (4.71)	0.2048*** (4.56)	0.1928*** (4.29)	0.1960*** (4.35)
DLNFERTILIZER	ln (fertilizer) if fertilizer > 0; 0 if not	0.2006*** (6.44)	0.1908*** (6.21)	0.1823*** (5.66)	0.1767*** (5.49)	0.1780*** (5.39)
DLNFERLA	ln (land) if fertilizer > 0; 0 if not	-0.0923** (1.99)	-0.0881* (1.93)	-0.0842* (1.75)	-0.0893* (1.86)	-0.0863* (1.80)
DLNFERIL	ln (labor) if fertilizer > 0; 0 if not	-0.1251*** (2.72)	-0.1034** (2.28)	-0.0740 (1.60)	-0.0724 (1.57)	-0.0663 (1.43)
DLNFERSE	ln (seeds) if fertilizer > 0; 0 if not	-0.0024 (0.00)	-0.0154 (0.28)	0.0245 (0.44)	0.0331 (0.59)	0.0264 (0.47)
DLNINSECTICIDES	ln (insecticides) in insecticides > 0; 0 if not	0.1086*** (3.39)	0.1047*** (3.32)	0.2674*** (4.70)	0.2995*** (5.17)	0.2990*** (5.16)

Table 34. Continued.

Variables		Coefficients				
Code	Description	B-1	B-2	B-3	B-4	B-5
DLNINSLA	ln (land) if insecticides > 0; 0 if not	0.0170 (0.28)	0.0078 (0.14)	0.0108 (0.17)	0.0139 (0.22)	0.0117 (0.20)
DLNINSTL	ln (labor) if insecticides > 0; 0 if not	0.1225** (2.55)	0.1165** (2.47)	0.0878* (1.77)	0.0852* (1.72)	0.0802 (1.62)
DLNTNSSE	ln (seeds) if insecticides > 0; 0 if not	-0.1486** (2.33)	-0.1412** (2.24)	-0.1739*** (2.73)	-0.1397** (2.16)	-0.1319** (2.03)
DLNMACHINERY	ln (machinery) in machinery > 0; 0 if not	0.0273 (0.3)	0.0189 (0.66)	0.0063 (0.22)	0.0424 (1.36)	0.0424 (1.36)
DLNMACHLA	ln (land) if machinery > 0; 0 if not	-0.0379 (0.62)	-0.0043 (0.10)	-0.0083 (0.14)	0.0236 (0.39)	0.0270 (0.44)
DLNMACHTL	ln (labor) if machinery > 0; 0 if not	-0.0630 (1.31)	-0.0831 (1.76)	-0.0715 (1.51)	-0.0639 (1.35)	-0.0612 (1.29)
DLNMACHSE	ln (seeds) if machinery > 0; 0 if not	0.1489** (2.43)	0.1476** (2.45)	0.1410** (2.35)	0.1249** (2.07)	0.1193** (1.97)
DLNANIMPOWER	ln (animal power) if animal power > 0; 0 if not	0.0131 (0.30)	0.0109 (0.26)	0.0083 (0.20)	0.0070 (0.17)	0.0076 (0.17)
DLNANILA	ln (land) if animal power > 0; 0 if not	-0.0014 (0.00)	0.0168 (0.32)	0.0115 (0.22)	0.0163 (0.32)	0.0160 (0.30)
DLNANITL	ln (labor) if animal power > 0; 0 if not	0.0020 (0.00)	-0.0121 (0.30)	-0.0134 (0.31)	-0.0157 (0.39)	-0.0165 (0.40)
DLNANISE	ln (seeds) if animal power > 0; 0 if not	0.0208 (0.39)	0.0248 (0.47)	0.0229 (0.44)	0.0249 (0.47)	0.0243 (0.46)
DLNFERIN	ln (insecticides) if fertilizer > 0; 0 if not			-0.2140*** (3.42)	-0.2307*** (3.69)	-0.2273*** (3.63)
DLNINSFE	ln (fertilizer) if insecticides > 0; 0 if not			0.0495** (2.07)		0.0522** (2.17)
DLNINSMA	ln (machinery) if insecticides > 0; 0 if not				-0.0778*** (2.70)	-0.0802*** (2.86)
CONSTANT		2.8460	3.0443	2.9504	2.9536	2.9569

[a]Values of the t-statistic are shown in parenthesis below each coefficient.

*Significant at 10 percent level.

**Significant at 5 percent level.

***Significant at 1 percent level.

other factors such as managerial superiority on large farms. The evidence with respect to both possibilities is entirely negative insofar as corn production in Guatemala is concerned. On the one hand, the results given in the preceding chapter indicate there is no systematic relationship between farm size and the use of modern technology. The results given in Table 34 suggest further that there is no difference in corn production efficiency associated with farm size.

It is often suggested that the productivity of family labor is lower than that of hired labor.[7] The results given in Tables 33 and 34 indicate otherwise. Out of the five technologies which allow separate estimation of a coefficient measuring variations in productivity associated with differences in the proportion of hired labor to total labor, only in the case of the Basic + Animal Power + Fertilizer technology can the hypothesis that labor is homogeneous be rejected (Table 33). In any event, such a difference in productivity, if it indeed exists, is insufficiently strong to be measured with statistical reliability once a pooling of sample observations is made (Table 34).

Both schemes utilized for the purpose of capturing land quality differences are relatively crude. Regions not only capture soil fertility differences but also other aspects such as sociological differences which might potentially affect cultural practices in corn production. Furthermore, there is considerable heterogeneity in land quality within each region. On the other hand, the proportion of broken land in the farm and the proportion of rolling land in the farm (the

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[7]A review of the arguments used and a test of this hypothesis employing data on Indian agriculture may be found in Bardhan [1973].

remaining land being characterized as flat land) are not defined in reference to the specific field in which corn is cultivated. Despite these limitations, use of these variables provides for a better understanding of corn production relationships in Guatemala.

Estimates of regional differences in productivity can be obtained for two technologies, i.e., Basic and Basic + Fertilizer + Insecticides (Table 33). The hypothesis that the regional classification employed makes no difference in corn productivity when the basic technology is used can be rejected at a low level of significance.[8] Differences in productivity between the five regions considered, however, are not estimated with much precision. The latter is particularly applicable to the estimates obtained for the Basic + Fertilizer + Insecticides technology, for which none of the coefficients which measure productivity differences

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[8]The significance level of a test is given by the probability of Type I (rejecting the null hypothesis when it is a true hypothesis). Kmenta [1971, p. 119] has noted that "there is nothing sacrosanct about the figure of 1% . . ." or, for that matter, about the other figures which are popularly used in the econometric literature as cut-off points between significance and insignificance.

The coefficients presented in Tables 33, 34 and elsewhere in this study are followed by one, two or three stars, depending on whether they are found to be different from zero at the popular levels of significance of 10, 5 and 1 percent, respectively. The discussion of results in the text generally regard differences between the estimated value and the null hypothesis (that the value of the estimated parameter is equal to zero) to be significant if the probability of Type I error is at least equal to 10 percent.

It should be noted that no formal test of the regional classification is presented here. That is, the value of the F statistic which might have been used to test the hypothesis, that of the four coefficients introduced to capture productivity differences between the Western Highlands and the other regions at least one will be different from zero, is not calculated here. Nevertheless, since two of these coefficients are individually found to be significant for the Basic technology (using individual t-tests), the value of that F statistic will also be statistically different from zero [Kmenta, 1971, p. 367].

between Region I and the remaining regions is found to be statistically significant.[9] For both technologies, the most notable finding is the low productivity of the Western Highlands when compared with the other regions considered.

The pooling of observations to estimate Model B allows for more reliable estimates of the influence of regional differences upon corn productivity. The Western Highlands is confirmed as the least productive region, whereas the West South Coast clearly arises as the most productive region. Parcels found on farms with a large proportion of broken land are least productive.

The effect of including non-flat land variables in the regression equations upon the estimated regional coefficients should be noted (Table 34, Equations B-1 and B-2). The explicit inclusion of land type variables is to reduce the productivity differences between Region I and the remaining regions. Thus, to some extent the perceived differences in regional productivities (particularly in Table 33 and Equation B-1 of Table 34) are a reflection of differences in the quality of land which accompany the type of land surface prevailing in the various regions.

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[9]The degree of precision of an estimate is measured here by the value of the t-statistic. Coefficients estimated with higher t values are regarded to be greater precision estimates than coefficients estimated with lower t values.

The arbitrariness involved in the testing of a hypothesis when no single equation can be specified to fully represent the structure of the model and when collinearity between explanatory variables may give rise to large standard errors should be recognized. If the value of the t-statistic is insufficiently large to reject the hypothesis that the parameter in question is different from zero at a relatively high level, say 10 percent, then as an alternative to accepting the null hypothesis and under the expectation that a larger sample size would reduce the standard error and show the coefficient to be significant, the estimated coefficient may be regarded to be a lower precision estimate.

Yet, after the inclusion of land type variables, the regional classification remains a statistically significant determinant of corn productivity. Thus, it cannot be ruled out that other differences, such as in cultural practices across regional boundaries, also underly the perceived regional differences in productivity.

The kinds of information available from the SFBCS do not allow discrimination of well defined technologies. From operational reports [Hutchinson et al., 1974] and conversations with some of DIGESA's promoters, it appears that indeed in 1973 a comprehensive, well specified and well tested set of technological recommendations was unavailable to the farmer, the DIGESA promoter or the BANDESA credit agent. Actual recommendations appear to have been of a general type, such as "fertilizers are good, particularly in the Highlands," and "machinery is not so good, unless it is being used on large farms with flat land." Accordingly, in the testing of H2, the question to be asked is whether the modern inputs generally promoted by the SCSG proved to be productive in practice.

It was shown in Chapter IV that the SCSG promoted the use of fertilizer and, to a lesser degree, the use of insecticides in the production of corn. From Tables 33 and 34, it may be seen that both of these inputs were significant contributors to corn productivity.

There should be little doubt that the use of fertilizer was a productive practice in the production of corn in Guatemala. Out of the five technologies in which it was used and for which separate production functions can be estimated, the hypothesis that the output elasticity of fertilizers is equal to zero can be rejected in four cases at a low level of statistical significance (Table 33). This result is confirmed

by the pooled estimate of the output elasticity of fertilizer in Table 34. This estimate is relatively high, positive and statistically reliable.

The results for insecticides are similar, though not as statistically decisive as in the case with fertilizers. For all of the four technologies for which a separate estimate of the output elasticity of insecticides can be obtained, the estimate is positive and, in one instance, estimated with high statistical precision. The pooled estimates of output elasticity in Model B are, with the exception of B-4, highly significant from a statistical standpoint.

It has been seen in the preceding chapter how the proportion of BANDESA farmers using improved seeds and machinery was larger than the proportion of non-BANDESA farmers using these inputs. This result came about primarily as the result of a general modernization effect. In practice, the SCSG tended to discourage the use of machinery, and its recommendations regarding the use of improved seeds appear to have been mixed. The results regarding the productivity of both of these inputs provide for a partial explanation behind the attitude of the SCSG with regard to these two modern inputs. An examination of the results given in Tables 33 and 34 indicates that, even though these inputs may have been productive, their effect upon production is estimated to have been neither significant nor statistically reliable.

From experimentation with Models A and B, the suspicions raised by H3 appear to be confirmed. Of the nine technologies for which a separate production function can be estimated the hypothesis that no difference in productivity can be associated with the BANDESA status of the farmer can be rejected in five of them at a reasonable level of

statistical significance (Table 33). Only for three technologies is the BANDESA coefficient estimated to be positive, but in every one of these cases the positive coefficient can hardly be considered significant. Moreover, while it appears that the number of BANDESA and non-BANDESA observations for the "Basic + Fertilizer" technology should have been sufficient to detect any differences associated with BANDESA status, the same cannot be said for the two other technologies which deviate from H3. That is, there were 111 BANDESA fields, in a total of 184 fields, practicing a "Basic + Fertilizer" technology, whereas there were only 16 BANDESA fields, in a total of 43, practicing a "Basic + Machinery" technology and only 10 BANDESA fields, in a total of 67, practicing a "Basic + Animal Power" technology. It should be noted that no specific technological feature can be identified with the negative productivity effect associated with BANDESA status. The effect appears in the simple technologies, such as the "Basic," as well as in the more complicated ones, such as the "Basic + Animal Power + Fertilizer + Machinery + Insecticides."

The negative effect associated with fields cultivated by BANDESA farmers is confirmed with a high degree of statistical reliability by pooling observations across technologies (Table 34). Simple participation in the BANDESA credit programs appears to assure the farmer of producing about 20 percent less corn than a non-BANDESA farmer employing the same technology. BANDESA farmers who received their credit on corn are somewhat compensated in terms of productivity, but about Q2000 of corn specific credit would be required to compensate for the negative productivity effect associated with BANDESA status. This figure

surpasses the average credit received by BANDESA farmers for corn production which is estimated at Q339 [O'Quinn et al., 1975].

Previous results on modern input use indicate that BANDESA participation induces the use of modern inputs. An explanation of the negative BANDESA coefficient could include a combination of the following reasons:

(a) The credit group inefficiently utilized those technologies which were new to them.

(b) The credit group wasted the additional capital by using a basic resource such as labor redundantly.

It is very difficult to determine the relative importance of these two possibilities. The fact that, among those farmers who used a basic technology, the inefficiency of BANDESA farmers can also be detected suggests that this inefficiency is not solely due to the first hypothesis above.

The evidence available on labor use in corn production at the farm level might suggest that the second hypothesis above is not a cause of the observed inefficiency. Whereas the mean use of labor in corn production by BANDESA farms was estimated to be about 72.5 days, non-BANDESA farms used about 72.2 days of labor. The hypothesis that mean labor use per hectare of corn production did not differ according to BANDESA status may not be rejected at a significant level of statistical reliability, i.e., $t = 0.07$ [McDonald, 1975, p. 14].

Nevertheless, a comparison of the labor used in fields of the same size by BANDESA and non-BANDESA farms tells a different story. Table 35 presents the results obtained from the estimation of a double log equation expressing labor per hectare used as a function of corn field size

and two BANDESA "shift" terms. The estimated parameters provide for measures of (a) the elasticity of labor use per hectare cultivated for non-BANDESA farmers (ε_N), (b) differences in this elasticity between BANDESA and non-BANDESA farmers ($\varepsilon_B - \varepsilon_N$) and (c) differences in the level of labor use between the two credit groups. The estimated equation is given in Table 35. Whereas no apparent difference in elasticity can be detected, the difference in level of use is significant. In Table 36, the results of the estimated equation are projected.

The difference in labor per hectare used between credit groups may well reflect the fact that BANDESA farmers utilized modern technologies which use labor intensively. It also coincides with the notion that redundant use of labor played a role in the observed BANDESA inefficiency. This result, in turn, indicates that part of the increment in employment per hectare observed at the farm level by the GFPA (see Chapter IV) constituted a loss in human resources. Note that in order to say that the redundant use of labor did not constitute a loss, it is necessary to accept the idea that the labor time redundantly employed in corn cultivation could not have been able to find useful employment in some other activity. The observed indifference in the productivity of family and hired labor in corn production suggests this idea to be implausible.

The observed inefficiency of BANDESA farmers has implications for private as well as for social profitability. Table 37 provides an estimate of the private rate of return of corn fields from participation

Table 35. Elasticity of labor use per hectare of corn cultivated, by credit type[a]

Item	Coefficients
ε_N	-0.32957^{***} (11.95)
$(\varepsilon_B - \varepsilon_N)$	0.03899 (0.97)
$(k_B - k_N)$	0.1467^{***} (3.10)
k_N	4.12072
F	83.441^{***}
R^2	0.18149
No. of observations	1133

[a]The elasticity estimates were obtained from the log linear regression of labor use per hectare of corn cultivated on non-interplanted corn area sown and corresponding parameter shifter for credit status:

$$\text{labor use per hectare} = C_i \text{ Area}^{\varepsilon_i}$$

where $C_i = e^{k_i}$ and k_i is a constant, for i = B(BANDESA), N(Non-BANDESA).
Values of the t-statistic are shown in parenthesis below each coefficient.

*Significant at 10 percent level.

**Significant at 5 percent level.

***Significant at 1 percent level.

Table 36. Predicted labor use per hectare in fields of varying sizes, by credit type

Size of field	Non-BANDESA	BANDESA
--Hectares--	----------- Days -----------	
0.5	77.41	87.25
1.0	61.60	71.34
2.0	49.02	58.32
4.0	30.01	47.68
7.0	32.44	40.53
10.0	28.84	36.54
20.0	22.95	29.87

Table 37. Corn: estimated per hectare yield, income, labor use and expenditure by region

Region	Yield[a]	Gross income[b]	Total labor	Gross expenditure[c]	Net income[d]	Private rate of return[e]	Observations
	-- kg --	-- Q --	- Days -	---- Q ----	-- Q --	-- Percent --	-- number --
I							
BANDESA	1795.6	205.7	99.9	95.9	109.9	11.8	106
Non-BANDESA	1570.7	168.9	92.1	62.9	106.0		128
III							
BANDESA	2050.0	220.3	93.9	83.3	137.0	204.8	28
Non-BANDESA	1487.8	138.6	98.4	56.5	82.1		37
IV							
BANDESA	1908.9	208.4	52.6	88.2	102.2	-87.1	140
Non-BANDESA	1698.1	204.4	51.0	57.2	147.2		130
V							
BANDESA	1498.1	184.4	54.1	73.4	111.0	-62.2	191
Non-BANDESA	1481.1	177.2	55.2	54.1	123.0		185

Table 37. Continued.

Region	Yield[a]	Gross income[b]	Total labor	Gross expenditure[c]	Net income[d]	Private rate of return[e]	Observations
	-- kg --	-- Q --	- Days -	---- Q ----	-- Q --	-- Percent --	-- number --
IV							
BANDESA	1481.7	170.9	52.6	68.5	102.4	-488.1	99
Non-BANDESA	1799.0	213.2	54.1	57.6	155.6		111
All Regions							
BANDESA	1741.7	195.0	68.2	82.4	112.6	-77.5	564
Non-BANDESA	1669.2	189.6	68.7	58.4	131.2		591

[a]These yield figures differ from those in Table 14 because the unit of observation in the present table is the field whereas in Table 14 it is the farm.

[b]Gross income: (output in kg x price/kg) ÷ size of field in hectares. Where no output price was observed, a mean price of Q0.215/kg was imputed.

[c]Gross expenditures: Σ quantity of input i x price of input i, where i = seeds, urea, fertilizers, insecticides, machinery, animal power, total labor. The observed price of seeds was used where available; otherwise, a mean price of Q0.215/kg was imputed. The mean regional price was used as the price of labor per day, i.e., in Region I, Q0.772; in Region III, Q0.931; in Region IV, Q1.230; in Region V, Q0.868; in Region VI, Q0.900. The mean regional price was used as the price of animal power per day, i.e., in Region I, Q1.62; in Region III, Q0.80; in Region IV, Q2.62; in Region V, Q2.53 and in Region VI, Q2.23. The mean price of Q0.131/kg was used as the imputed price of urea and other fertilizers.

[d]Gross income minus gross expenditures.

[e]Private Rate of Return: (Net income BANDESA - net income non-BANDESA) ÷ (gross expenditures BANDESA - gross expenditures non-BANDESA) X 100.

SOURCE: Calculations were done using the methodology developed in Daines et al. [1976, Vol. II, pp. 41-53].

in the BANDESA credit program.[10] This measure of profitability is rather limited because it focuses on the corn field rather than the farm as the unit of observation. Thus, it ignores important changes which may have occurred within various farm activities and which would tend to have important implications for total private profitability. For example, whereas the mean area planted to corn on BANDESA farms was estimated to be equal to 3.68 hectares, the comparable figure for non-BANDESA farms was only 2.84, a difference which is statistically significant at the 99 percent level, i.e., $t = 2.51$ [McDonald, 1975]. Nevertheless, the results in Table 37, which indicate that private profitability at the level of the corn field was negative in Regions IV, V and VI and relatively low in Region I, should be regarded as very discouraging from the standpoint of the SCSG. Given the emphasis placed on raising the productivity in the production of basic grains, it is difficult to conceive how social profitability might have been enhanced by the SCSG. It would appear that the positive changes occurring in other farm activities which would be needed to compensate for the negative results observed in corn productivity and profitability would have to be quite large.

To what extent can this inefficiency of BANDESA status be generalized to other crops? A basic model equation for a selected number of crops for which a reasonable number of observations were available has been estimated. The evidence presented in Table 38 is inconclusive.

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[10] To use a measure of profitability which reflects (within the information available) the opportunity cost of factors, rather than administered prices, a mean price of labor and area has been used. Also, all labor whether family or hired has been priced at the same rate.

Table 38. Estimated coefficients, production functions of selected crops[a]

Variable		Coefficients by crop			
Code	Description	Wheat	Rice	Sesame	Sorghum
DLNTECHAS	ln (number of technical assistance contacts) if number > 0; 0 if not	0.15559*** (3.02)	0.04876 (0.50)	0.60385*** (3.39)	0.34150 (1.05)
LNSEEDS	ln (quantity of seed used)	0.03439 (0.74)	0.30896*** (3.57)	0.20499* (1.79)	0.29997 (1.54)
LNLAND	ln (size of field)	0.47387*** (11.20)	0.70121*** (6.39)	0.60150*** (4.13)	0.39981 (1.32)
LNLABOR	ln (total labor used on field)	0.00718 (0.1)	0.10111 (1.33)	0.49695*** (3.06)	0.32858 (1.64)
DBANDESA	1 if BANDESA; 0 if not	-0.10723 (1.51)	-0.12308 (1.12)	-0.79261*** (4.06)	-0.24516 (0.72)
DIMPSEED	1 if improved seeds; 0 if not	-0.09762 (1.0)	-0.00833 (0.0)	0.75733*** (3.71)	-0.15144 (0.55)
DREG3	1 if in Region III; 0 if not	---	---	0.09947 (0.36)	---
DREG6	1 if in Region IV; 0 if not	-0.06417 (0.62)	-0.07772 (0.61)	---	0.03596 (0.10)
LNFAMILY	ln (proportion of family to total labor)	-0.04169 (1.06)	0.05543 (1.08)	-0.07496 (0.73)	0.09279 (0.68)
Constant		6.88942	5.77496	2.72489	4.91674
F		89.62***	60.88***	22.12***	10.92***
R^2		0.76034	0.80100	0.6755	0.63605
No. of observations		235	130	145	59

[a]Values of the t-statistic are shown in parenthesis below each coefficient.

*Significant at the 10 percent level.

**Significant at the 5 percent level.

***Significant at the 1 percent level.

For all four crops considered, the difference in productivity between BANDESA and non-BANDESA is negative; but, only in the case of sesame can the estimate be regarded to be statistically reliable.

The results given in Tables 33 and 34 also shed light on the empirical validity of H5. The simple classification of farmers between those who received and those who did not receive technical assistance in corn production employed in the separate estimation of production functions (Table 33) does little to dispel the notion that technical assistance made no difference. The pooled estimates of Table 34, however, test whether the number of contacts which the farmer had with technical assistance personnel in relation to corn production made a difference in productivity. Indeed, it appears that the originators of the SCSG were correct in assuming that technical assistance made a difference. Nevertheless, about 20 contacts of technical assistance appear to be required to offset the negative effect associated with a BANDESA status.

CHAPTER VI
SUMMARY AND RECOMMENDATIONS

Summary of Results

Between 1960 and 1976 gross domestic product in Guatemala grew at a real rate of about 5.6 percent per year, similar to the relatively high growth rate experienced by Latin America as a whole. The macroeconomic difficulties it encountered in the 1970's, primarily related to the country's vulnerability to the vagaries of its external sector, were easily weathered, thanks to the overall economic health which the country enjoyed. Nevertheless, the highly skewed personal distribution of wealth and income constituted a major problem facing Guatemala's leadership and threatened to disrupt the country's tenuous political and social stability.

A strategy for increasing the participation of Guatemala's rural poor in the commercial economy and for improving their welfare would tend to involve two basic components. First, the resources of the country's lowlands could be tapped and a redistribution of wealth effected, through land reforms in the Pacific Coast or through the colonization of the yet unsettled humid tropics of the Franja Transversal and Petén. Secondly, efforts could be made to raise the productivity of small farmers who, for the most part, practiced traditional agriculture. The National Development Plan 1971-75 recognized the problems of income distribution facing Guatemala and adopted both

means of improving the welfare of its rural poor. But, probably in recognition of the economic and political limitations of land reform and colonization schemes, the plan emphasized the transformation of traditional agriculture. An important feature of the plan was the reorganization of public agencies serving agriculture and their integration into the agricultural public sector (Sector Público Agrícola). Some old agencies were fused, some new ones were created, means of coordination were defined and, most importantly, new functions and orientations were assigned. Foremost in importance to the plan's rural development strategy were the activities of the credit agency, BANDESA, and of the extension service, DIGESA. Their coordinated action constitutes what in the present study is referred to as the Supervised Credit System of Guatemala (SCSG).

The system was designed to overcome the principal obstacles which the plan identified as preventing the transformation of traditional agriculture. Modern and efficient agricultural practices were noted to exist. An underlying premise of the plan was that, if traditional farmers did not use these modern practices, it was because they lacked the capital with which to purchase the modern inputs on which these practices depended and because they were unfamiliar with the proper use of these modern inputs. Accordingly, the system combined the provision of BANDESA credit to small farmers with the technical supervision by DIGESA's promoters of the proper use of such credit. The credit and technical assistance was provided on a crop specific basis and the interest charged on the loans was lower than the market rate.

Crop diversification was an important component of the original program's effort to raise productivity per hectare and to expand the

country's export base. But, as disbursement of funds aimed at stimulating the production of non-basic crops proved to be slow and as the production of foodstuffs gained priority as a concern of Guatemala's decisionmakers, the amounts of the assistance granted in support of basic grains in general, and corn in particular, were substantially increased.

The recommendations built into the individual farmer's production plan varied on the basis of individual agents' assessments of the specific conditions under which individual crops were cultivated. In general terms, the use of fertilizers, insecticides and improved seeds was favored. In contrast, the use of machinery was regarded as inappropriate on Guatemala's small farms, particularly in the highlands where the terrain is predominantly rugged, and was regarded to be labor substituting, and thus potentially erosive of the labor absorptive capacity of agriculture.

Despite the system's emphasis on increasing yields, the evidence available for a cross section of farmers from the Small Farmer BANDESA Credit Survey (SFBCS) suggests that in 1973 the system failed to meet this objective. In the five regions considered, only in the Western Highlands is there reliable statistical evidence suggesting that the yields of BANDESA credit farmers were higher than those of non-BANDESA farmers.

Why then did the SCSG fail to bring about significant increases in yields? The present study has sought to answer this question by determining whether the SCSG was effective in inducing farmers to use modern inputs and in assisting farmers to make effective use of the chosen technology in the production of corn.

The theoretical foundations of the SCSG are reviewed in Chapter II of the present dissertation. There it is shown that under reasonable conditions a modern technology which is potentially profitable is unprofitable in the short run for small farmers facing a capital constraint. Thus, adjustment from a low level productivity equilibrium in which farmers employ a traditional technology to a high level productivity equilibrium in which farmers employ costly modern inputs, which are highly profitable from a societal standpoint, can be accelerated through the provision of institutional credit.

Despite the theoretical basis underlying the SCSG, in practice the implementation of the system was accompanied by institutional restrictions on the use of the credit funds which the farmers received. In general these restrictions appear to have selectively prescribed the use of some inputs while it discouraged the use of others. Moreover, compliance with these restrictions was to have been monitored by DIGESA promoters, who, in addition, were to have served as disseminators of modern agricultural practices.

The fact remains that the corn yields of BANDESA farmers failed to be significantly higher than those of their non-BANDESA counterparts. In principle this could have resulted from farmers having used their credit for purposes other than those agreed upon in their original commitment with BANDESA agents. If so, it would appear that DIGESA's promoters also failed to communicate the advantages of the modern technologies to the credit farmers. Accordingly, two hypotheses tested in the present study are:

H1: Credit was not a factor inducing the use of selected modern inputs.

H4: DIGESA's promoters were ineffective in inducing the use of selected modern inputs.

Alternative reasons which could explain the exhibited failure of credit to significantly raise the corn yields of BANDESA farmers and which are plausible within the Guatemalan context are the following:

H2: A technology making effective use of selected modern inputs did not exist.

H3: The levels of productivity attained by BANDESA credit farmers using the recommended technologies were lower than their full potential.

Regardless of whether effective modern technologies existed and were effectively used by some farmers, it is unclear why the technical assistance provided by DIGESA failed to significantly raise the productivity of BANDESA farmers. Hence,

H5: DIGESA's promoters were unsuccessful in improving the technical efficiency of the farmers they served.

The hypotheses H1 through H5 are tested within a multivariate framework and the results are given in Chapters IV and V of the present dissertation.

In Chapter IV it was assumed that the decision to use or not to use each of four modern inputs, namely fertilizers, insecticides, improved seeds and machinery, is dependent upon the value of an index which is a linear function of age, years of schooling, region in which the farm is found, distance to market, farm size, relative dependence on corn, BANDESA credit status, amount of credit provided for corn production, number of contacts made with technical assistance personnel in relation to corn production and interaction effects between the four modern inputs.

In Chapter V the certainty assumption implicit in the analysis of Chapter II is relaxed and accounts for the dispersion in the levels of use of the various inputs in terms of differences in the expectations of farmers regarding future output. An econometric model of production is formulated which permits the testing of H2, H3 and H5. Technologies are defined and depend on whether a particular combination of four non-basic inputs is used by the farmer: animal power, machinery, fertilizers and insecticides. Separate production relations are assumed to hold true for each technology. Three basic inputs are used in each technology: land, labor and seeds. The use of improved vs. local seeds was assumed to affect production directly through shifts in the multiplicative term of each production relation. To ensure unbiasedness in the testing of the hypotheses of interest, other factors potentially influencing production are considered: regional location of farm, proportion of non-flat land on farm, proportion of family labor to total labor employed and farm size.

Chapter IV provides considerable evidence in support of the rejection of both H1 and H4. On balance, the BANDESA credit program in conjunction with DIGESA's technical assistance, i.e., the SCSG, is <u>associated</u> with <u>increased use of the four modern inputs</u> considered. Nevertheless, the evidence suggests that the SCSG <u>did not promote</u> the use of <u>every</u> one of these inputs. Instead, the various aspects of the SCSG appear to have been <u>inducive</u> of <u>selected</u> modern inputs.

With varying degrees of statistical reliability the evidence suggests that the use of fertilizers and the use of insecticides were induced by participation in the BANDESA credit program, by the amount of credit which some BANDESA farmers received on corn, and by the number

of contacts of technical assistance on corn provided by DIGESA promoters.

Results are somewhat confusing regarding the effect of the SCSG as an inducer of the use of improved seeds. Simple participation in the BANDESA program appears to be unrelated to the use of improved seeds. The additional working capital provided by corn specific credit does appear to induce the use of improved corn seeds. The evidence suggests, however, that DIGESA's promoters might have been recommending against the use of improved seeds.

The SCSG seems to have had more unity of purpose with regard to the use of machinery. Participation in the BANDESA program, larger amounts of corn specific credit and more numerous contacts of technical assistance on corn, all seemed to have worked against the use of farm machinery.

These results lend support to the theory developed in Chapter II, with one qualification. Indeed, the availability of working capital at low rates of interest may have generally made more profitable than otherwise the use of modern inputs and induced their use. But, the negative inducement effect of credit upon machinery use requires clarification. One plausible reason for this exception may be found in the power of institutional constraints. For, regardless of how much more profitable an input may be made through the provision of credit at subsidized interest rates, it is possible that the system devised as part of the SCSG for monitoring the use of credit in compliance with an approved work plan for each farm may have deterred its use. In effect, the positive inducement effects of credit upon the use of selected modern inputs are likely to have been as much the result of the

inducement of the added profitability as the institutional constraints imposed by participation in the SCSG.

The results regarding the contradictory effect upon the use of improved seeds by different aspects of the SCSG also lend credence to the doubts raised by a number of observers of Guatemalan agriculture. At the time of inception of the SCSG there does not seem to have been a unified set of prescriptions for agricultural technology. Instead, there appear to have been some general guidelines which recommended the use of fertilizers, particularly in the Highlands, and the use of insecticides, particularly along the coast. The guidelines discouraged the use of machinery, particularly in non-flat small farms. There were conflicting views with regard to the use of improved corn seeds.

A number of the adjustment variables considered, i.e., schooling, age, distance to market and farm size, proved to be of relatively minor significance compared to the impact of the SCSG upon the use of modern inputs. In contrast, the proportion of land used to grow corn and differences in the condition which prevail in the various regions identified were significant determinants of modern input use. Also, there appears to have been a tendency for the four modern inputs to be used together. If a farmer used one of the four modern inputs, he was more likely to have used the other three.

Evidence given in Chapter V suggests the rejection of H2 and H5, but not H3. There is evidence that some productive technologies employing modern inputs made a difference in corn productivity. Furthermore, the evidence also suggests that technical assistance on corn also helped improve farmer productivity. The perplexing result is the statistically reliable finding that BANDESA farmers were significantly less

productive in the production of corn than their non-BANDESA counterparts.

BANDESA farmers, compared to non-BANDESA farmers, had the advantage of employing more modern inputs proven to be effective in raising productivity. This was particularly true of BANDESA farmers whose credit was provided for use in corn production. Moreover, BANDESA farmers, who received corn specific credit and technical assistance, had an added productivity advantage directly related to the amount of credit they received and the number of contacts of technical assistance made. Still, with the exception of farmers in the Western Highlands, the corn yields of BANDESA farmers were not much higher than those of non-BANDESA farmers. The negative productivity effects found to be associated with participation in the BANDESA credit program provides for a partial explanation of the failure of the SCSG to fully meet its objective of increasing yields.

Failure to reject H3 is, nevertheless, an unexpected result which deserves closer scrutiny. It is difficult to understand why the mere fact of receiving credit should result in reduced productivity. One possible explanation considered in Chapter V is that credit farmers used new technologies with which they were unfamiliar and failed to use them as effectively as non-BANDESA farmers who were more practical in the use of these technologies. Such an explanation, however, is incomplete. A comparison of farmers using basic inputs only also exhibits the productivity advantage of non-BANDESA over BANDESA farmers.

Literally interpreted, the results show that, for similar quantities of the various inputs used under a given technology, a lower output was obtained by BANDESA farmers than by non-BANDESA farmers. In practice,

however, BANDESA farmers used more labor per hectare of corn cultivated than non-BANDESA farmers in fields of similar size. Together, these findings suggest that BANDESA farmers were using some labor redundantly, i.e., to obtain the same level of output non-BANDESA farmers were using less labor. Moreover, such a response would not appear to be the consequence of a normal response to economic incentives. The price equations presented in Chapter IV indicate that wages paid by BANDESA farmers were higher than those paid by non-BANDESA farmers.

Why then were BANDESA farmers using labor redundantly? First, it is important to note that the subsidization of credit to BANDESA farmers has the effect of lowering the opportunity cost to the farmers of all of the inputs he uses, including labor. Accordingly, the apparently higher wages paid by BANDESA farmers may not have acted as an important determinant as they would have had credit not been available at a subsidized rate.

Secondly, even though credit was granted on a specific crop basis, credit for one crop released resources, e.g., labor, for use in other crops. This interpretation is in keeping with the finding that BANDESA farmers receiving credit and technical assistance on corn fared somewhat better in terms of corn productivity than BANDESA farmers receiving assistance in other crops. Though the latter may have also used some labor redundantly, the work plan prepared and the special attention given to corn production may have prevented them from suffering the more serious loss in corn productivity exhibited by BANDESA farmers who received assistance in some other crop.

Recommendations

In view of the findings of the present study, the following recommendations are offered:

1. It is important to continuously review the extent to which the central objectives of samll farm assistance programs are being furthered as implementation procedes. The intermediate objectives of SCSG focused on promoting the use of modern inputs on small farms as a means to increase yield. Yet, "To assume that the key to improving the conditions of the small farmers is to provide credit for the purchase of annual inputs is a very dubious proposition" [Arenas and O'Sullivan, 1977, p. 14]. In fact, the SCSG proved to be effective in inducing modern input use among relatively small farms but fared rather poorly in raising yields. Most importantly, by concentrating efforts on these intermediate objectives, the attainment of other more central objectives such as increasing economic efficiency may have been thwarted.[1]
2. Future credit programs should be justified on a more solid technical basis than the one on which the SCSG appears to have been based. The present study has demonstrated that conditions may be envisioned under which the provision of institutional credit may be justified as a means to accelerate the rate at which small farmers adopt new productive technologies. Three necessary conditions are: (a) the existence of new and

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[1]For a thorough discussion of the relationship between "final impact objectives," "intermediate objectives" and "institutional building objectives," see Daines [1975b] and Tendler [1972].

profitable technologies that are suitable for the conditions under which small farmers operate, (b) a clear understanding of the processes through which these technologies can be disseminated widely and a knowledge of the costs of these processes, and (c) the existence of undeveloped rural capital markets. The evidence available suggests that the justification presented in support of the SCSG was based on a very cursory review of the extent to which these three conditions were fulfilled. In particular, the evidence reviewed in the present study suggests that even though some corn technologies which used modern inputs and which were effective in the sense of being productive did exist, these did not appear, for the most part, to have been profitable. Also, while some general agronomic principles appear to have been understood by extension agents, there is little evidence that they had clear guidelines as to the technologies they were to disseminate or the conditions under which they applied. Furthermore, credit was made available at a subsidized rate and not just at the commercial market rate as might have been required to break up monopolistic holds in rural capital markets.

3. It is difficult to ascertain from the available evidence the extent to which credit subsidies to small farmers may have constituted one of the few politically feasible means for making income transfers from persons with higher incomes to the rural poor families. Nevertheless, in terms of economic efficiency, the provision of credit at subsidized

rates appears to be unjustifiable. The present study has looked briefly at private profitability at the level of the corn field and concluded that participation in the BANDESA credit program did not provide a net private return which compensated factors of production at their opportunity cost. BANDESA farmers may have used the new technologies indeed expecting their productivity to be below that of non-BANDESA farmers who used the same new technologies. The incentive for BANDESA farmers to use these technologies could well have been provided by the subsidization of capital which had the effect of lowering the price which BANDESA farmers had to pay for their inputs. On the other hand, BANDESA farmers may have expected to reach a higher level of productivity (similar to that attained by non-BANDESA farmers) which did not materialize. If so, this expectation could have easily accounted for the relatively high rate of delinquency in loan repayment which has troubled BANDESA.

4. A successful strategy for rural development in Guatemala should, as the National Development Plan 1971-75 did, include the transformation of traditional agriculture as an important component. The diversification of agricultural production is an important part of such a component. But, the domestic market imposes limits on the rate at which such diversification can take place, and the commercial sophistication required to tap export markets is outside the reach of most traditional farmers. Accordingly, a

strategy for improving the incomes of farmers practicing traditional agriculture should encompass the promotion of agricultural practices which aim to raise the farmer's productivity in the production of those crops and crop-systems with which the farmer is familiar and for which increases in supply can be absorbed by the market at a profitable rate of return.

5. What is most important is that the objective of small farm assistance programs be to improve private, economic and social profitability. The SCSG appears to have operated on a very narrow crop orientation which imposed institutional restrictions upon small farmers' initiatives. Instead, future programs should try to enhance the profitability of the entire farm as a system of mutually supporting activities, rather than concentrating on raising yields.[2] For example, credit should be provided on the basis of a farm plan rather than a crop plan. This plan should be used as the basis for identifying credit needs. Once the credit has been made available, the farmer should be given the freedom to use his judgement to respond to economic conditions as they vary over time. The technical assistance expert should be trained in farm management principles to ensure that he looks first and foremost at

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[2]Other sutdies [e.g., Daines, 1975b; Tinnermeier, 1973] have also criticized the overemphasis of small farmer credit programs on raising yields. Given the results of the present study, it is important to reiterate this criticism.

profitability, and that he considers not only the increase in yields but also prices of the outputs and prices of the inputs. Also, while the function of supervising credit to ensure that it is repaid is a legitimate and important one, it does not appear to be wise for it to be confused with the role of technical advisor. After all, the best way of ensuring the repayment of loans is for the credit funds to be profitable. And, in the case of the SCSG, it appears that the paternalistic form of supervision adopted may have prevented farmers from attaining a higher level of profitability.

Similarly, future programs should be designed in a way that will ensure that the costs of implementation, i.e., the total costs of making the capital and the technical assistance available to the small farmers, are more than compensated for by the net income increase achieved at the farm level. Given the finding that, on balance, field level profitability on corn obtained from participation in the BANDESA credit program was insufficient to pay for the increases in input costs associated with such participation, it is doubtful that a more comprehensive evaluation which took into account all charges brought about by the SCSG at the farm level, and which recognized the costs of implementing the SCSG, would alter the basically negative appraisal of the impact of the SCSG presented in this study.

Finally, if the provision of credit is being used as an income transfer mechanism, it would seem important to explicitly consider the costs and benefits of other alternative means of redistributing income. In so doing, the economic inefficiencies which may result from the provision of credit to small farmers, as documented in the present study, should be explicitly recognized as a social cost.

6. Where unemployment affects a large proportion of the rural poor, the use of public investments (e.g., through the provision of institutional credit to small farms to create jobs for these social groups) may constitute a politically attractive way of increasing national income and redistributing wealth. Nevertheless, not all employment creation should be deemed to be good. In the case of the SCSG, it appears that much of the labor which was used, at least in the production of corn, was used inefficiently. That is, BANDESA credit farmers used more labor than did non-BANDESA farmers to produce the same quantity of output. Whether this result should be regarded as a net social loss depends on what the opportunity cost of labor is. Even if the alternative to such employment is leisure, it is doubtful whether the value of leisure is zero. More likely, however, there may have been a loss in output from a reduction in off-farm activities.

7. There are major differences in the agronomic, economic and cultural conditions which characterize agriculture in the various regions of Guatemala. Future program design should

take cognizance of these differences. Agroeconomic research, for example, needs to be differentiated depending upon whether it is aimed at developing technologies suitable for highlands conditions or for the tropical agriculture prevalent in the lowlands.

8. The fact that credit and technical assistance can be powerful instruments inducing modern input use may be most useful in future program designs. What needs to be recognized, however, is that modern inputs may be used one time but perhaps nevermore. This may happen, for example, if they fail to provide an adequate financial return to the farmer. In the case of the SCSG, the pricing of inputs and subsidization of capital may have enabled participating BANDESA farmers producing corn technically inefficiently to make an adequate return. What is not clear is whether their productivity will improve over time as they make better technical use of the modern inputs and of the greater quantities of inputs which the credit enables them to use. If they do not, once the subsidies are removed, they will most likely return to their old traditional, and under the circumstances, more efficient ways.

9. Future research efforts should expand upon the present study in several ways. First, an attempt to trace the impacts of the SCSG upon the direct objectives of that program, the present study has focused on those changes which were induced upon the production of a single crop. In so doing, some of the conclusions presented by previous evaluations of the SCSG,

principally the GFPA, have been shown to be misleading. Nevertheless, additional insight would be gained from a comprehensive appraisal of the SCSG which takes into consideration all of the changes which were induced by implementation of that program. An appropriate framework for such an appraisal would involve the determination of the actual rate of financial, economic and social return which the investments undertaken yielded, and an analysis of the factors which exerted a major influence on costs and benefits.[3]

Second, the present study has presented an explanation of behavioral responses to increases in credit availability which relies on a certainty model. Such a model is useful for the purpose at hand as it helps demonstrate that under reasonable conditions it made economic sense for the public sector to provide institutional credit in an attempt to accelerate adoption of newly developed technologies. Nevertheless, uncertainties regarding the returns from the adoption of modern technologies are central and deserve added attention in future work. An expected utility framework would shed additional light on adoption behavior. From an estimation standpoint it would be important to consider the extent to which output variances vary with tehcnologies and with BANDESA status.

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[3]For a recent and thorough review of project appraisal methodology see Helmers [1979].

Third, it is only recently that international donor agencies have begun to make post-implementation evaluations of projects that are as significant as the SCSG. The need for such evaluations for the light they may shed about future program design cannot be overemphasized. Furthermore, project design should include data gathering activities which later on facilitate such post-implementation appraisals. To the extent that such data gathering activities may be combined with the record gathering efforts which are usually undertaken as part of project execution, time series data that may be used to trace the effects on program participants (and on control groups) would be collected more economically and probably would be more reliable.

APPENDIX

NOTES ON REGRESSIONS, PRESENTED IN TABLES 17, 28, 33, 34, 35 AND 38, ON MULTIVARIATE LOGIT ANALYSIS, PRESENTED IN TABLE 27, AND ON CORRESPONDING DEFINITIONS OF VARIABLES USED

1. The unit of observation in all regressions is the non-interplanted corn field. This violates the classical least squares assumption of independence of error term. Clearly, production in two fields cultivated in the same farm by the same entrepreneur will not be independent. On the other hand, two such fields are not cultivated under exact technical and climatological conditions so that they do add information about the production process. The latter argument suggests that a loss of information would result if the inputs and outputs of the two separate fields were to be considered as a single observation. The correct procedure would be to account for the correlation in the error term between two fields cultivated in the same farm.

   Nevertheless, Generalized Least Squares procedures have not been used, given that the number of offending observations is small. Of 1031 farms which cultivated at least one non-interplanted corn field, only 51, less than 5 percent, cultivated two such fields. The actual degree of autocorrelation will, of course, depend upon the particular equation. Where the number of observations used is limited--e.g., price equations--the estimates should be regarded as "first" approximations.

2. The unit of observation in the logit analysis is the farm, with aggregation over fields within a farm where pertinent.

3. The following are definitions of the variables used in the regressions and in the logit analysis. The cell number of the Guatemala questionnaire from which the observation was obtained is also provided.

Cell Numbers	Variable Names	Definition
I.D.	DBANDESA	1 if BANDESA 0 if non-BANDESA
145, 146, 147	DNMTECHAS	Number of contacts of technical assistance
145, 146, 147	DLNTECHAS	ln (Number of contacts of technical assistance) if number of contacts greater than zero 0 if number of contacts equals zero
145, 146, 147	DTECHAS	1 if number of contacts of technical assistance greater than zero 0 otherwise
137	CORNCREDIT	Amount of corn credit from BANDESA sources
046	DIMPSEED	1 if improved seeds were used 0 if not
116-125	LNFAMILY	ln (man days of family labor ÷ man days of total labor)
116-125	LNHIRED	ln (man days of hired labor ÷ man days of total labor)
025, 031-033	ARABLE	Arable land on farm
025, 031-033	DSIZE	1 if amount of arable land greater than 10 hectares 0 otherwise
036-038	BROKN	Proportion of broken land on farm
036-038	ROLL	Proportion of rolling land on farm
047	LNLAND	ln (size of field)
116-125	LNLABOR	ln (total man days of labor)
074, 076	LNSEEDS	ln (quantity of seeds used)
080, 082	DURFERT	1 if fertilizer or urea was used 0 otherwise
080, 082	DLNFERTILIZER	ln (quantity of urea and other fertilizer used) 0 if no urea or fertilizer was used
080, 082, 047	DLNFERLA	ln (size of field) 0 if no urea or fertilizer was used

Cell Numbers	Variable Names	Definition
080, 082 116-125	DLNFERTL	ln (man days of total labor) 0 if no urea or fertilizer was used
080, 082, 074, 076	DLNFERSE	ln (quantity of seeds) 0 if no urea or fertilizer was used
086	DINSECT	1 if insecticides were used 0 otherwise
086	DLNINSECTICIDES	ln (value of insecticides) 0 if no insecticides were used
086, 047	DLNINSLA	ln (size of field) 0 if no insecticides were used
086, 074, 076	DLNINSSE	ln (quantity of seeds used) 0 if no insecticides were used
093, 095, 097, 099, 101	DMACH	1 in machinery was used 0 otherwise
093, 095, 097, 099, 101	DLNMACHINERY	ln (number of passes of "tractor-like" machinery) 0 if no machinery was used
093, 095, 097, 099, 101, 047	DLNMACHLA	ln (size of field) 0 if no machinery was used
093, 095, 097, 099, 101, 116- 125	DLNMACHTL	ln (man days of total labor) 0 if no machinery was used
093, 095, 097, 099, 101, 074, 076	DLNMACSE	ln (quantity of seeds used) 0 if no machinery was used
109, 047	DLNANILA	ln (size of field) 0 if no animal power was used
109, 116-125	DLNANITL	ln (man days of total labor) 0 if no animal power was used
109, 074, 076	DLNANISE	ln (value of insecticides used) 0 if no animal power was used
086, 080, 082	DLNFERIN	ln (value of insecticides used) 0 if no fertilizer or urea was used
086, 080, 082	DLNINSFE	ln (quantity of urea and other fertilizers used) 0 if no insecticides were used

Cell Numbers	Variable Names	Definition
086, 093, 095, 097, 099, 101	DLNINSMA	DLNMACH if insecticides greater than zero 0 if insecticides equals zero
086, 116-125	DLNINSTL	ln (quantity of labor used) 0 if insecticides equals zero
109	DLNANIMPOWR	ln (days of animal power used) 0 if days of animal power equals zero
I.D.	DREG34	1 if in Region III or in Region IV 0 otherwise
I.D.	DREG3	1 if in Region III 0 otherwise
I.D.	DREG4	1 if in Region IV 0 otherwise
I.D.	DREG5	1 if in Region V 0 otherwise
I.D.	DREG6	1 if in Region VI 0 otherwise
010	DISTANCE	Distance to markets where the majority of sales and purchases are made
002	EDCN	Years of schooling of farm head
047, 025, 031-033	CORNFLA	Proportion of arable land on farm dedicated to corn
001	AGE	Age of farm head in years

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BIOGRAPHICAL SKETCH

Francisco J. Proenza was born in La Habana, on December 19, 1947. He lived in Cuba until April 28, 1960, at which time he accompanied his parents to exile in Mexico. Late in 1961 he moved to Florida where he graduated from high school, Miami Dade Junior College and the University of Florida. He currently resides in Washington, D.C. He has worked as an economist with the Sector Analysis Division of the United States Department of Agriculture (1975-1976) and with the Organization of American States (1976-present) on problems of economic and agricultural development in Latin America and the Caribbean. Mr. Proenza married Emma M. Echenique on December 28, 1971. Together they have two beautiful children, Pablo, aged 6, and Javier, who is 10 months old.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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